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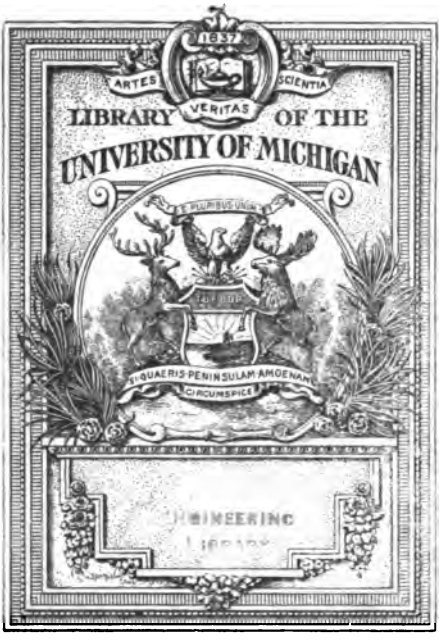
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British Association of Gas Managers.

REPORT OF PROCEEDINGS

OF THE

FIFTEENTH ANNUAL MEETING,

HELD AT THE

SOCIETY OF ARTS ROOMS,

JOHN STREET, ADELPHI, LONDON.

JUNE, 1878.

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BRITISH

ASSOCIATION OF GAS MANAGERS.

REPORT OF PROCEEDINGS,

ETC., ETC.

The Fifteenth Annual General Meeting of the Members of this Association was held in London, on Tuesday, the 18th, and Wednesday, the 19th of June, 1878, at the Rooms of the Society of Arts, John Street, Adelphi—CORBET WOODALL, Esq., M.I.C.E., the President, occupying the chair.

TUESDAY, JUNE 18.

The PRESIDENT took the chair at ten o'clock this morning.

The minutes of the last general meeting, and the statement of accounts, which had been previously printed and circulated, were taken as read, and confirmed.

NEW MEMBERS.

The SECRETARY (Mr. W. H. Bennett) read the following list of names of gentlemen applying for membership:—

ORDINARY MEMBERS.

Broadberry, W. F.	Southend.
Canning, T.	Newport, Mon.
Carpenter, S.	Bow Common.
Carter, H. W.	Winsford.
Chapman, J.	Harrow.
Chester, W. R.	Greenwich.
Culver, G.	Hythe.
Daley, W.	Invercargill, N.Z.
Darney, R., jun.	Bournemouth.
Davis, G. J.	Birmingham.
Dawson, W. C.	Arundel.
Dozell, H.	London.
Halkett, R.	Bicester.
Irvine, G.	Ripon, Yorks.
Latchford, W. J.	Broadstairs.
Leather, J. P.	Burnley.
Linging, F. E.	Norwich.
Marshall, F. D.	Brentford.
Newton, A.	Hong Kong.
Palethorpe, W. W.	Doncaster.
Parker, G.	Oakengates.
Parsons, S.	Bury.
Sheppard, T. L.	Farnworth.
Shonbridge, S. Y.	Birmingham.
Walker, J.	Colney Hatch.
Wilshaw, W. G.	London.
Wilson, R.	Croydon.
Wood, W.	Colnbrook.
Yates, E.	Shaftesbury.

EXTRA-ORDINARY MEMBERS.

Booth, J.	Hazelhurst.
Chandler, J.	London.
Chandler, S.	London.

EXTRA-ORDINARY MEMBERS (*continued*).

Davies, F.	London.
Davis, G. E.	Manchester.
Richardson, W.	Newcastle-on-Tyne.
Stephenson, A.	London.
Wallace, R. W.	London.
Woodward, J.	Manchester.
Young, J. R.	Newcastle-on-Tyne.

On being put to the vote, the whole of the above were unanimously elected Members of the Association.

The PRESIDENT then proceeded to read the following

INAUGURAL ADDRESS.

Permit me, before proceeding to the business of our meeting, to express my cordial thanks for the honour you have done me in electing me to this chair. I regard the position of President of the British Association of Gas Managers as the highest open to members of our profession, as such, and I value accordingly the confidence you have been pleased to repose in me.

I occupy the chair this morning with much of personal misgiving, but with strong confidence in your generous help. I earnestly hope that this may prove not the least interesting and profitable of the gatherings of our Association, and that throughout there may be manifested a vigorous interest in the matters under consideration, combined with perfect harmony and mutual respect.

I have felt for several years past that the time at our disposal for these annual meetings is too short; very soon I hope it may be possible to extend the three days to at least four. In the meantime, in order to get the maximum of advantage out of our short session, it is necessary that all the time possible should be given to the papers and discussions, and it is to this end especially that I shall need to ask your watchful and constant co-operation. Our formal and official business must necessarily occupy some rather considerable time; but, I venture to suggest, not so much as it has occasionally done. I hope also that gentlemen who purpose speaking on any particular subject will immediately avail themselves of the first opportunity for so doing.

It is very gratifying to observe the continued growth and prosperity of our Society. The success which has attended it throughout has been remarkable and uninterrupted, and our numbers have increased so rapidly that we shall soon be shut out from the possibility of obtaining more recruits, because all the men will have been enlisted. We find also less difficulty in obtaining papers; the quality of the communications is fully maintained, and our discussions become more general.

Our members last year, according to the list published with the proceedings, were—

Honorary Members	10	
Ordinary ,,	579	
Extra-ordinary Members	48	
In all		637
Of that we have since lost—		
By the operation of Rule XXXVII.	8	
Withdrawn	7	
By death	2	
		17
Leaving at the commencement of this meeting a total of		620
We have now added—		
Honorary Members	5	
Ordinary ,,	29	
Extra-ordinary Members	10	
Old Members reinstated in the list on payment of arrears	2	
		46
Total		666

The members whom death has removed were Mr. John Holloway, of Springfield, in Ireland, and Mr. John Rofe. I had not the pleasure of knowing personally either of these gentlemen, but the name of Mr. Rofe had been familiar to me from the commencement of my professional life. Those who knew him well speak with respect of his ability, and with esteem and affection of his personal character. He was for a quarter of a century Engineer to the Preston Gas-Works, but retired from that position some years ago because of failing health. Our Association testified its respect for Mr. Rofe by electing him, in 1864, one of its first Honorary Members.

Our muster-roll is such as few scientific or technical societies can point to, as the growth of so short a period, and it is one of which we may be justly proud. At the same time it puts upon us an obligation to furnish fruit worthy of so fair a tree; for a crop that would be creditable to a young vine in its early days, would be unworthy of it when a dozen years in passing had helped it to maturity of strength and vigour.

Of the fruit already borne, not the least important, in my opinion, is the foundation, in various parts of the kingdom, of district Associations, with objects similar to our own.

Our Society is perhaps young to undertake the cares of maternity; but a mother she is, and that of a rather large family. The anxiety of the parent is less than it might have been, because the children are so remarkably strong and healthy—indeed, they remind one of that prodigious birth recorded in classic story, when Minerva issued full-armed from the brain of Jupiter, rather than the ordinary and prosaic method, so little have they manifested of the dependence and weakness of infancy.

That these Associations may prosper abundantly we all truly hope. They have one material advantage in being able to meet more frequently than is possible with us, the members having to be drawn from shorter distances. These more frequent meetings not only give time for more careful consideration of the subjects brought forward, but they also tend to the formation of friendships, most useful and pleasant, among men who, though living near each other, might, without such aid, remain as perfect strangers as next-door neighbours are supposed to be in London.

As to the influence of these Societies upon our own, I entertain no fear that it will be anything but favourable. The stronger the individuals become, the better for the body in which they are united. The one evil that occurs to me as possible is, that members, finding it impossible to prepare two papers, may give preference to local claims, and we may run short in consequence. This is not likely, but, to put it out of question altogether, I would suggest that each District Association should charge itself with the responsibility of furnishing from among its members at least one paper annually to the parent Society. If this suggestion be adopted, not only shall we be sure of abundant matter, but there will be an element of friendly rivalry introduced that must have a beneficial influence on the quality.

Some concern has been expressed on recent occasions at the fact that our financial balance has slightly diminished. Although the accounts of the past year show an improvement in this respect, yet it is not a considerable one, and I venture to ask that there may be a still larger response to the invitation given by our past Presidents, that such members as can afford it will increase their subscriptions to a guinea. I do not ask this on the ground that it is desirable to increase our reserve materially, but because we should be lifted beyond the necessity of discussing reduction of useful expenditure, and because also we have by no means reached the limit of profitable spending. This is a matter that has never caused me the least concern, because I know that we all feel too deep an interest in, and affection for, our Society to allow it really to suffer on this ground.

Looking at the enormous importance of the gas industry now, it is hard to realize that the generation which saw the incorporation of the first Gas Company has not yet passed away. (Our astonishment is not diminished, but increased, when we remember that the same is true of the railway system, and many other of the great industries giving employment to the Civil Engineer.) Year by year, with steady strides, the demand for gas has advanced, and with it the demand for gas-makers. In the earliest

days of gas lighting, men had to feel their way step by step, and many years were occupied in bringing the manufacture to anything like a complete system. For a long time the business of gas-making was regarded by the general public as something secret and mysterious, and the management was in the hands of a very limited number of men. By degrees, however, this condition of things has been altered, and the study of the construction and management of gas-works is as open as any other branch of engineering to whoever chooses to enter upon it.

I make these remarks because I wish—treading in the steps of several of my predecessors in this chair—to draw the attention, especially of our younger members, to the growing necessity for thorough preparation on the part of those who are to follow, and obtain success in the profession of Gas Engineering. I say nothing on the question of early education; that is a matter over which the student has usually little control. Happy is he whose parents are able and willing to afford him a good one; for the youth whose mind has been trained to concentrated and systematic work, starts with as great advantage over one not so fortunate, as in a race a public-school athlete would have over a ploughboy. But it is after school has been left behind, and actual work has been commenced, that a man's training frequently begins. Under the spur of felt necessity, of active competition, he can do much in his hours of leisure to fit himself for a successful career, and under such stimulus the ploughboy does sometimes come to the front. But remember, gentlemen, it is not *as* the ploughboy. The men who "make their own way," in spite of early disadvantages, do so at a cost of labour and toil out of proportion to what it might have been, and honoured should they be in the same degree. All such men put a high value upon early training, and readily admit that they would have been the better for it. The early years lost cannot be made up for; duties and responsibilities grow, and a man finds his time fully occupied in meeting these, and none left for catching up arrears. I readily admit that this has always been the case. What I urge is, that the question of training becomes year by year of greater moment; "rule of thumb" less possible; and, to quote a remark of Mr. Bruce Bell, "an uneducated engineer is as likely to succeed as an uneducated schoolmaster."

In our case, the growth of the business of Gas Companies involves the necessity for works of constantly increasing magnitude, and this again brings added responsibilities in management and control, as well as the necessity for further acquaintance with the principles of construction, while the demand for refinements of purification, coupled with the obligation to avoid offence on the works, makes still further demands on the care and ability of the Manager.

Then also the Legislature has from time to time, as the natural development of our industry and the improvements and economies effected by the Companies have rendered it possible, reduced the maximum price chargeable for gas; every such reduction making it more imperative that those interested with the management should be alive to the progress effected, should know what is being done by others, and be capable of comprehending and applying for themselves processes which tend to improve or cheapen production, and thus to the advantage of their employers and the public. In short, gas-making is in the same category with all other great industries of a scientific nature in this respect, that year by year the demand upon those who conduct it, for increased intelligence and skill, becomes greater; while the steadily improving character of the general education of the country causes the race to be keener and the competitors to be more in number for the prizes which it has to offer.

To help us carry forward our profession, at least in line with the general progress around us, is the mission of this Association, and although it cannot take the place of individual effort, it can, and does, worthily second it.

If such is the work of our Society, it has an interest and a value to Gas Companies as well as to ourselves, and I am very glad to know that this is now widely recognized. I would strongly advise all members who are Managers of works to make a point of specially reporting to their Committees or Directors upon the work done at each of our sessions. In this way an intelligent interest in our proceedings will be maintained, and

employers will see that the money spent in paying their officers expenses to our meeting is well invested.

The subject of remuneration is one that I feel we can do little good by discussing here. It is one to be settled by the two parties to the engagement, and will be governed, to a large extent, by the law of supply and demand in the first place, and by the proved value of the officer himself subsequently. There is one aspect of the question, however, upon which, with your forbearance, I will say a few words.

In the JOURNAL OF GAS LIGHTING, No. 715, appeared the following remarks:—

"It seems to be a common belief that all gas officials are highly paid, but no grosser delusion ever prevailed. There are a few—very few—who receive well-earned, large salaries; but we repeat, without fear of contradiction, that a vast majority of Gas Managers are most inadequately rewarded. They are required to know something of many arts, and several sciences. They can hardly be said to have peace night or day, and, at times, their duties are of a most onerous character; and when they have done all, they often receive less than a banker's or a merchant's clerk, who has only to make entries and add up figures from ten to four o'clock. Struggling Companies may have some excuse for parsimony; but, if we might select some of the worst cases of inadequate payment, we should take them from our corporate towns. Here, too, it may be said, there is an excuse, for we have recently read of indignation meetings being held to remonstrate against the addition of £50 a year to the salary of a most valuable gas officer.

"We feel bound to insist on this matter, for, in our opinion, it lies at the bottom of all the mischief of which complaint is now made. Pay a man well, and then you may expect or require him to be immaculate. It is, from a moral point of view, sad to think that men require to be bribed, as we might say, to be honest; but such, in a limited sense, is the fact. You must place men above temptation before you can expect them to resist it."

This, as many will remember, formed part of an article dealing with the question of the payment and acceptance of commissions, which had been raised in the columns of *The Times*, and other papers, and was continued in the JOURNAL. I refer to it here from a conviction that the subject is one that materially affects both our reputation and our prosperity. That inadequate salaries justify the acceptance of commissions, no one here will, I think, maintain; but that they increase the temptation cannot be questioned.

I wish, however, to point out that, while small salaries tempt to commissions, commissions tempt to small salaries. It does happen, and will continue to happen so long as the system remains at all, that some men will be found willing to accept duties at inadequate remuneration, purposing to make up by this means, while those who decline commissions have to be content with such salaries as would be accepted by the former class. The restriction of salaries is not the only wrong the system does, for it brings undue suspicion on those who do not join in it, and makes possible wholesale charges of a most unjust nature.

The acceptance, by a paid agent of a principal, of fixed or more or less well understood per centages on the value of goods purchased, or contracts made, is as morally indefensible as any system of bribery, and yet who does not know how plausible are the arguments used by those who offer them? It is pleaded that they are only a deduction from the profits, and no loss to the principal whose agent receives them. But I would ask, supposing these payments to be abolished, by what special arrangement of political economy would competition be prevented from reducing prices by their amount?

In a leading article in *The Times* of the 6th inst. appear the following passages:—"The practice of receiving commissions has been pronounced illegal in every way, and this in terms which will make it impossible for any man to meddle with it with a notion that he can be acting honestly. A usage, however prevalent, which is declared to be corrupt in itself, and opposed to common morality, must be held to go far beyond the doubtful border-line at which impropriety begins. The man who can receive a commission, and not be biassed by it, who can form as independent a

judgment as if he himself had no personal stake in the matter, and can look after his employer's interests as sincerely as if he had not been paid for betraying them, must be so rare and so superhuman an exception, that the Queen's Bench Judges were fully justified in not enlarging the law on his account. It is obvious, too, that to one side or the other a commission must be unjust. If the receiver of it does the work he is paid for, it is his principal who will suffer. If he takes it and does nothing for it, it is hard to see what sort of defence he can make for putting it, thus unearned, into his pocket. But, whatever the exception may be, there is no doubt as to the rule which will hold good in ninety-nine cases out of one hundred, if not in the hundredth too. His judgment, if he cares to think about the matter at all, will be influenced in the way intended, and he will give advice which is not the best, or will accept terms which are less favourable than they might have been. The arbiter who receives a bribe is not held to be excused, even if he can make out that he has remained indifferent in spite of it. There was a breach of trust committed in the mere receiving it, and it is idle in such a case to speculate on what the after consequences may or may not have been."

I must ask your indulgence for entering on a subject so delicate, and in many ways distasteful. I have done it because I felt that to pass it by was the graver fault.

I know that there is no special reason for addressing such observations to Gas Managers, more than to any other body of commercial or professional men. I know also that the statements that have been made as to the general prevalence of the custom are gross calumnies; but so long as commissions are offered and accepted, I think it our duty to protest against them. That many employers lend themselves to the practice they condemn, by paying salaries below the value of services rendered, there can be no doubt; that some even wink at the custom, as justifying them in such a course, is, I am told, a fact. But no such circumstances make it one whit less objectionable; they do but show more broadly its pernicious effect. I have never heard other than one opinion expressed on this matter by Managers or Manufacturers, and that of Directors can admit of no doubt; all alike condemn the practice and deplore its results. Mutual jealousies on the one side, and possibly respect for ancient usage on the other, keep it alive. In expressing a hope that the custom may soon be entirely surrendered, I feel sure of the concurrence of this assembly.

I have to congratulate you on the list of papers submitted this year for our consideration; they are all devoted to matters of great interest, and will deserve all the time we can give to them. At the same time, though there is not one of the list that we would wish displaced—and we certainly have not room for more—I do regret the absence of papers descriptive of works of a mechanical or engineering character, in progress or recently completed. Members are constantly engaged in the construction of new apparatus or buildings, and the materials are consequently never wanting. Such works occupy much of our time and thought, and would be as profitable in discussion as any that could be chosen; while we all recognize the important bearing which the judicious expenditure of capital has on the success of a gas undertaking. I presume that Mr. Livesey's paper will treat of this latter subject, and it is one worthy of his able pen.

I have already referred to the demands which gas engineering increasingly makes upon constructive ability and scientific knowledge; but the fact must not be lost sight of that gas-works belong to what are essentially commercial enterprises, depending for success, to a remarkable degree, upon the manner in which engineering and science are directed, and even held in check by economic considerations.

There must be, for instance, but a sorry sort of satisfaction to the man who finds himself in charge of works, admirable in design and workmanship, and replete with every modern improvement, but necessitating the imposition of a sum, equal to seven or eight times the net cost of coal, to pay the statutory dividend thereon. I am not exaggerating when I say that there are places to be found where the coal, less residuals, costs but 8d. or 4d., and a 10 per cent. dividend, 2s. to 2s. 6d. per 1000 cubic feet of gas sold; or, in other words, the dividend alone, in one town, may absorb a sum nearly equal to the selling price of gas in another, and yet the

management in each case may be equally efficient, and all the manufacturing charges the same, the whole difference being due to the disproportionate expenditure on plant in one case as compared with the other. The time was when comparatively little heed was given to this aspect of our business. Works were erected, a statutory price sufficiently high was obtained, and that was a successful undertaking which paid full dividends. But the publication of the analysis of London Gas Companies accounts by Mr. Field has brought home to every Manager a ready means of comparison, and has no doubt imbued many with a healthy spirit of competition.

I am disposed to think that if ever the public did suffer on account of the monopoly of Gas Companies, that can now only be the case in very rare instances, most Companies regarding themselves as in competition with every other similarly circumstanced, and striving to excel in providing superior advantages to their consumers. On these grounds, Mr. Livesey's paper will be of much value, if it goes to determine the relation that capital should bear to revenue.

Mr. Methven's paper will be listened to with interest, as promising a solution of the vexed question of a true standard for photometrical observations. Mr. Methven has brought his mind with his eyes to the photometer, and I think you will consider the result very satisfactory. I hear with much pleasure that we are to be favoured also with a description of the means by which Mr. Vernon Harcourt has sought to reach the same end by the preparation of a gas of constant quality.

Permit me to refer to one other of the papers on our list. Some weeks ago, at the invitation of Mr. Carpenter, I visited Sheerness, and saw there the system of retort-setting and arrangement for automatic feeding which he is to introduce to you. I do not now express an opinion as to the probable success of Mr. Carpenter's plan; of that you will be able to judge from his drawings and model, even if the paper should not be reached. I simply wish to express my hearty admiration of the care with which the arrangement has been worked out, and of the perseverance with which it has been followed up, under circumstances of no encouraging character. When members have the thought to conceive, and the courage to spend time, labour, and money in carrying out an idea which promises to result in improvement, this Association will always give its praise and help, even though the scheme be denied success. In no direction, I do not hesitate to say, notwithstanding the trials that have been made and the failures that have resulted, can the inventive skill of Gas Managers be more wisely directed than towards the attainment of a good plan of continuous carbonizing. That it will be done some day I have no doubt, and even many failures should not turn us aside from the search after what might prove, in economy, efficiency, and accuracy of manufacture, an illustrious step forward.

The past year has seen no alteration in the course of parliamentary dealings with Gas Companies, and it is a sign of the times that this should be a matter for remark. So many have been the changes and modifications of the treatment dealt out by Committees, in recent years, that there has resulted a feeling of unrest and expectancy which is much to be deplored, and which is grossly unfair. The consistency of the last two sessions I would characterize as a persistent continuance in ill-doing; for the imposition of auction clauses, which all Companies have had to submit to, is, to my mind, unjust in the extreme. I cannot see any reason why a body of men, who have borne the expense and run the risk of founding a business, and who have diligently cultivated that business until it has become a successful one, should then be required to take in, on even terms with themselves, any one who chooses to invest his money in a good thing. I quite admit that, taken in conjunction with the sliding scale of dividend and price, as we at present know it, they are less objectionable than they would be without it, because with a fixed price, the smaller the capital upon which dividend is to be paid, the larger, naturally, will be the dividend. But there is no more finality about the normal price than there has been with the maximum price of past years. Grant, then, that Parliament may re-arrange the price, taking advantage of the economies effected by the reduction of nominal capital through the operation of the auction

clauses, and the sliding scale ceases to be a compensation. Personally, though I express the opinion with much diffidence, I prefer the legislation of 1847 to any of the schemes which have in turn been substituted. I deny altogether that any inducement to economy and enterprise was required other than was afforded by the natural desire to increase our business, and, consequently, the capital invested in it. Under that Act the dividend has been in late years practically secure, so long as the works were properly conducted; and, while the Company gained the advantage of increased business, the consumer had, as he was fairly entitled to have, the advantage of such economies as were effected. The Act also furnished the Local Authorities with machinery amply sufficient to enable them to have examined the accounts of the Companies, and so see to it that the consumers had all they were entitled to. It is much to be regretted these powers were not used; had they been, there would probably have resulted more of trust in the *bona fides* of the Companies. I maintain emphatically that the Companies have striven loyally to carry out their obligations to the consumers, and that they have good reason to be proud of the success which has attended their efforts. It is not just to say that Directors have been concerned only to obtain maximum dividends, because latterly the maximum dividend has been regularly earned. My experience has been, and I believe yours will confirm it, that there has been a disposition to encourage, rather than otherwise, investigation into such matters as promised advantage to the consumer, and inventors have not had occasion to complain of rejection without trial. I regret the change; the new system brings with it an element of gambling. Shareholders will be constantly "asking for more," and weak officers will be tempted to wrest accounts so as to gratify them; while a rise in the price of coal, accompanied, as has happened before now, by a fall in the value of products, would leave the recent investors with barely any return for their money. I make these remarks because, especially, I object to the arguments on which the change was based. The Companies have laboured hard and honourably in the past; they will continue to do so, I doubt not, in the future, and that irrespective of the legislation by which their profits are controlled.

During the year there have been several cases of transfer of gasworks from Companies to Corporations, and, generally, both sides have been content with the terms. There are two or three matters of interest in connection with these, to which our friend Mr. William Livesey has kindly directed my attention, which I will shortly name.

The Corporation of Clitheroe agreed to pay to the Gas Company there the sum of £2887 10s., by way of bonus, for the uncalled portion of their shares, thus recognizing a position which the auction clauses annul. There has been a doubt frequently expressed in past years as to whether, in the event of a Company being unable to pay their maximum dividends, the reduction should be proportionate on each class of shares, or fall entirely on the original ones; this has been decided in favour of an even reduction over all ordinary stocks.

There are several new provisions intended to fence the auction clauses from abuse—that only a certain amount of capital shall be called in any one year, that the shares shall be offered in lots of not more than £100, and paid up within three months.

It is remarkable, however, that, notwithstanding the auction clauses, the dividend on new capital is restricted to 7 per cent. A share entitled to 10 per cent. dividend will always command a higher proportionate premium than one that is only entitled to 7 per cent., and therefore it seems to me clearly a mistake to fix on the lower rate.

I have little to say in relation to new processes or inventions. It is the less necessary that I should do so, as the "Treatise on Gas Lighting," now being published by Mr. King, has brought the record of improvements really effected close up to the day of our meeting, and in the columns of the JOURNAL we have, from week to week, full information upon any matter of interest affecting our business. I understand that our friend, Mr. King, will be absent this year from the post he has occupied at the table at each of our previous meetings. I am sure you will all join with me in wishing him fully re-established health, and in congratulating him

upon the deserved success which has attended his important work. Let me here acknowledge also the obligation under which we, as an Association, rest to Mr. King for giving us such help in the use of the JOURNAL type, as enables our proceedings to be published in the form we have them, and at a price within our means.

Our fellow-member, Mons. Brémond, of Versailles, has presented to the Société Technique a most admirable and exhaustive paper on the subject of the cause and cure of naphthaline. The experiments there detailed seem to support fully Mons. Brémond's theory, and I believe that subsequent trials on a larger scale have established the success of his method. This is a matter for congratulation, not only to the patentee, but also to gas-makers generally. The theory is that an excess of the vapour of naphthaline is kept in suspension in the gas by the presence of aqueous vapour, and that as the latter falls, through diminished temperature, the former falls with it.

It may readily be imagined that if a gas containing the vapour of a volatile body, together with aqueous vapour, be cooled, and the aqueous vapour is deposited in the liquid condition, this circumstance may determine, at the same time, the deposition of some of the vaporized body, even though the temperature necessary for the deposition of the latter substance alone has not been reached.

There is one aspect of the question, however, which is now receiving a considerable amount of attention, and the settlement of which may cause many of us to alter our practice in condensation. Mons. Brémond, after noting the fact that naphthaline is a result of high heat in the retort, goes on to approve the custom generally prevailing, of keeping the gas in contact with tar for as long a time as possible, so that the latter may absorb the naphthaline. This advice is somewhat peculiar, seeing that by adopting the process of desiccation, which forms the subject of his patent, the naphthaline is retained in the gas to its palpable advantage. Mr. Newbigging, in a letter to the JOURNAL OF GAS LIGHTING of the 4th inst., calls attention to the injurious effect upon the illuminating power of gas, resulting from intimate contact between it and tar, in the process of condensation, due to the absorption, not only of naphthaline, but of other hydrocarbons. That letter furnishes a concise examination of the whole question, and is of great value. Now the harmonizing of the two objects is made practicable by Mons. Brémond's system, and the result would probably be even more favourable than he promises. Remove the tar before it has commenced the absorption of gaseous hydrocarbons, dry the gas at the outlet of the purifiers, and the result would give, not only the 6 per cent. increase of illuminating value due apparently to the withdrawal of aqueous vapours, but a further per centage due to the retention of naphthaline. On this matter we shall certainly hear more at our next meeting.

As the paper prepared by Mr. Marshall, on purification by liquids, will deal with the process of Messrs. Wallace and Claus for utilizing carbonic acid, in which I feel a great interest, it is not necessary that I should refer to it here.

Messrs. Evans and Sugg are engaged in experiments—the lines of which have been explained in the JOURNAL OF GAS LIGHTING—for purifying gas by means of ammonia obtained from gas liquor, but I am not able to say how far success has yet attended their efforts. The preparation, either of caustic ammonia, or ammonium sulphide, from ordinary liquor is a difficult and costly process, and is the barrier in the way of success in this direction.

Much interest has recently been felt and expressed in a proposal made by Mr. St. G. L. Fox, and illustrated by a practical experiment in Pall Mall, to light simultaneously the lamps of a district by means of electricity. It is certainly painful to see the waste of gas—and especially such good gas as we all make—necessary, under the present system, where some lamps must be lighted in broad daylight in order that all may be kindled before dark; but this is, of course, a simple question of balancing the value of gas against the cost of lamplighters time. Mr. Fox proposes to connect, say, 200 lamps in one electrical circuit, and the action of his apparatus is thus described by the *Telegraph Journal*:—

"Each lamp is provided with a small induction coil of the ordinary make, without, however, a condenser or a contact breaker. The primary wire of each coil is in the circuit of the line wire, so that a current sent through the latter traverses the primaries of all the coils of the set of lamps on a circuit.

"The secondary wire of each coil has one end connected to the pipe, and the other brought in close proximity to the burner of each lamp, so that if the gas were turned on at each, and a powerful momentary current were sent along the line, and consequently through all the primaries, induced currents would be set up in all the secondaries, and these currents would make themselves manifest in the form of sparks jumping from the end of the wires on to the burners, and the gas at each lamp would thereby be lighted.

"To turn the gas on and off at each lamp, Mr. Fox makes use of the core of each coil. This, when magnetized by a current of moderate strength, causes a permanent magnet, attached to a stopcock of peculiar construction, to be rotated on an axis, and thereby to turn the gas on. If the current be reversed, the movement of the permanent magnet is reversed, and the gas is then cut off.

"The action of the apparatus is as follows:—When the lamps are to be lit, a positive current, say from a few cells of any kind of battery, is sent through the line. This magnetizes the iron cores of each of the induction coils, and the permanent magnet being thereby rotated, the gas is turned on. A momentary powerful positive current is now sent through the line. This sets up the induced currents in the secondaries, and the sparks from them light the gas. To turn out the gas, the current from the small battery is sent in the reverse direction to what it was in the first instance, and the permanent magnets being caused to rotate in the reverse direction to what they were at first, the gas is turned off."

The whole apparatus is very ingenious, not the least so being the cock, which Mr. Fox has designed to offer as slight frictional resistance as possible. He makes the plug slightly less in size than its socket, and filling the annulus with glycerine, finds it sufficiently sound, and at the same time free to move with very slight force. Assuming that success attends Mr. Fox's efforts to perfect the apparatus, there remains the question of pecuniary advantage. The margin, after paying for cleaning and repairs of lanterns, amounts to about 12s. per lamp per annum, out of which has to be paid interest on the rather large expenditure, maintenance of much delicate machinery, and the costs incident to the central station and the generation of the current. If these can be met without exceeding the present cost, the charming effects that would be produced nightly by its adoption should turn the scale in favour of Mr. Fox's invention.

I will now ask your attention, for a few minutes, to a question which has attracted increasing attention during the past year, and which is one of much interest to us, though having no direct connection with gas. I mean the electric light, and its possible influence upon Gas Companies.

The strides that electrical science has taken in recent years have been so great, that promises held out in its name are received with much respect, and it is not to be wondered at that great expectations are founded upon comparatively small achievements.

Although the electric light was discovered by Davy in 1813, it was not publicly exhibited, I believe, as a light likely to have useful applications, till about 1846, and even then the necessary electrical current was obtained from a galvanic battery. Now the battery, with its chemical action, has given place to mechanical force in the magneto-electric machine, where power and motion are transmuted into electricity. For a description of these machines, I will refer you to some articles which appeared in the JOURNAL OF GAS LIGHTING in December last, or to a paper read by Dr. Paget Higgs before the Society of Arts, and reported in their *Journal* of April 5 of this year. To the improvements which have been effected in magneto-electric machines, is largely due the present position of the electric light. Take an illustration from the report of Dr. Tyndall and Mr. Douglass of the Trinity House, on the lighting of the South Foreland lighthouse.

Late in 1876 these gentlemen made a series of experiments to determine

the relative value of various machines, in order to qualify themselves to advise the Elder Brethren as to the most suitable one for their adoption. For some years previous to that date, the light had been supplied to the South Foreland by a machine of the construction patented by Professor Holmes, and the fair inference is, that it was, when adopted, the best procurable. The result of the trial, against a machine made by Messrs. Siemens, which proved the best, was as follows:—

Comparison of Electrical Machines.

—	Cost.	Weight.	Horse Power.	Total Light.	Light per Horse Power.
	£	Cwt.			
Holmes	550	51	3·2	1523	476
Siemens	100	3¾	3·3	4138	1523

From these figures it will be seen that, on the important item of first cost of apparatus, the comparison stood thus:

Sum required to produce light of 1000 candles—

Prior to 1876	£361	0	0
Present time	24	0	0

or in proportion of 15 to 1.

The importance of so considerable a reduction in charge for plant needs no comment. So far, however, these advances have barely any special interest to us, for the light produced from each machine, equal to from 700 to 1000 candles as a minimum, was necessarily concentrated in one centre, and the sphere of its application was consequently very limited. The great power of the light was its weakness. But we are told this difficulty is being removed, if it has not already vanished. Various methods have been devised for breaking up the current from one machine, so that many lights may be supplied from it, presumably of less intensity, and consequently more adaptable to general use. Now, I venture to say that the progress made in this direction is practically almost *nil*. What has been accomplished is, so far as I understand it, as follows. Some makers have succeeded in so constructing large electrical machines that it is possible to establish several complete circuits from each. In other words, four or five machines are rolled into one, and on to the circuit of each of these wires can be attached several (say, five) lamps or candles, and in this way one machine supplies 20 lights. But I need hardly point out that this is not subdivision of the light. Each of the lamps so supplied is as powerful as would be one supplied direct by a small machine, and the extinction of one lamp puts out all the others on that circuit.

It would appear that the minimum power and intensity of the electric current necessary to the formation of the Voltaic arc is such that a light of moderate power is not attainable. But the fact remains that the light is now applied in various places, especially in Paris, in substitution for the light of gas.

An influential Company have been established in Paris for the purpose of introducing electric lighting, and the beautiful invention of M. Jablochkoff —the electric candle—is the property of this Company. Thanks to their energy, and that of their able Director, M. Denayrouze, the light is to be seen applied under many different conditions—in the streets and open places, in the courtyard of an hotel, in workshops and show-rooms, in public gardens, and the theatre.

In all these places the total light provided is vastly in excess of what was obtained from the gas formerly used, and the effect is naturally so much better. Especially in the streets, we will all agree that more light would not be thrown away, even in London. In some large open spaces, such, for instance, as the Place de l'Opéra, where the lamps must needs be far apart, the electric light has a decided advantage over gas as usually burned, because it more thoroughly illuminates the broad spaces between lamp and lamp. But this is a very small matter, and one that, if raised by the Street Authorities, and accompanied by a proffer to pay for more light,

could probably be met by our friend, Mr. Sugg, who would bring out yet another new burner.

Taking, however, the best illustrations afforded of the use of the electric light in places where, for the moment, the gas-burners have been turned off before it, we see how impossible it is for it to do more than touch the fringe of our business. The necessity for using it in centres of great intensity involves also the necessity for fixing these foci at considerable distances apart, and this again that there shall be wasteful expenditure of light at the centre, if there is to be sufficient at the extremity of the field. The law on which photometric observations are based—viz., that the value of a light diminishes as the square of the distance it is removed from the point to be illuminated—explains this clearly. Suppose a room, 100 feet by 20 feet, needing to be lighted to a certain minimum extent, which is met by gas-burners of 16 candles value, lighting a radius of 10 feet, clearly five such burners would fully illuminate the room, and the candle power used would be 80. If the light must needs be given from one centre, and that in the middle of the room, the total would have to be as the square of 50 is to that of 10, or as 25 to 1, giving 400 candles against the 80. But, if this one light is pushed back to the wall of the room, then, in order to get an effect at the opposite end equal to that given by the 16-candle burner, its value must be increased in the proportion of the square of 100 to that of 10, or as 100 to 1. The result of this is that while the light of 80 candles distributed would give the desired amount of light, 1600 candles, concentrated in one spot, at the extremity of the field, would be required to do the same work. The excessive brightness at the point where the light was centred would be so much waste, and an embarrassment rather than an advantage. Bearing this in mind, the electric light is certainly more costly than gaslight.

Take another illustration. I have here a letter from a firm of Engineers in France, who have for some time used electric lamps in their erecting shop, which is 145 feet long by 36 feet wide. There are two lamps used, giving a light said to equal 3800 candles, and they are fixed at a height of 30 feet from the floor. (Such a position as this, on premises where power is always available when light is wanted, offers the greatest inducement to the adoption of electricity.) The cost, taken from the users figures, is as follows:—

Cost of machines and lamps	£208	0	0
Power required to drive same . Five horses.			

Cost per Year, 500 Hours Burning.

Interest at 12 per cent. to cover maintenance	25	0	0
Carbon, 9·4 in. × 500 × 6½d.	10	12	0
Coal, 4½ lbs. per horse power, at 21s. per ton .	5	4	0
Supervision, 500 hours at 3·3d.	6	17	6
	£47	13	6

or 22·9d. per hour.

But if we add to this what my correspondents have left out, because they had not specially to provide it—viz., cost of engine, boiler, setting and chimney, say £200 for the 5-horse power-engine, 10 per cent. on for maintenance and interest, adds £20 to the annual charge, making it £67 13s. 6d., or 32·5d. per hour.

I will assume the greatest amount of light to be required at a height of 4 feet from the floor, that 60 6-feet burners are distributed along the shop in 6 rings of 10 each, at a height of 12 feet. These would give out a light equal to 960 candles. The cost of this would be—

60 × 6 × 500 = 180,000 cubic feet of gas, at 3s. 4d. . .	£30	0	0
Interest on fittings, £30 at 10 per cent.	3	0	0
Total	£33	0	0

or £14 13s. 6d. per annum less than electricity. But such a gaslight would be regarded as extravagant to a degree. It would be equal, at the point I have specified—4 feet from the floor—to more than twice that of the

electric light, if we regard light alone, and allow nothing for the superior diffusion of the light from many gas-burners. The equation would be—

$$8^2 : 26^2 :: 960 : 10{,}140;$$

while the lamps only gave 3800. Thus twice the useful light would be had for half the cost. Remember also that this comparison is between gas which has paid its manufacturers full dividends, and the cost price of the electric light with no charge upon it even for distribution.

In this case the electric current was used in the most economical manner—viz., the whole strength of a machine concentrated on one light.

I am unable to furnish any exact figures as to the cost of lighting, by the system of M. Jablochkoff, with lights of less power; but it is certainly, light for light, largely in excess of the direct one. The division of the current, I am assured, involves both increased power and diminished light, and the carbons also are much more expensive. As an instance, I saw a room, about 80 feet by 60 feet, which had been satisfactorily lighted by 48 gas-burners using about 5 feet per hour. In one night of six hours these would consume $48 \times 5 \times 6 = 1440$ cubic feet, which, at 3s. 6d. per 1000, would be equal to 5s. The gas had been displaced by 8 electric lights, in which the "candles" were changed every hour, and each cost, I was informed, 5½d. A night of six hours in this case would, therefore, cost, for carbons only—

$$8 \times 6 = 48 \times 5\tfrac{1}{2}\text{d.} = £1\ 2\text{s.}$$

Thus the carbons alone were costing (if I was rightly informed as to their price) more than four times the total cost of the gas. Add to this, interest on cost of machinery, cost of some 10-horse power absorbed in generating, payment of stoker and "gas man" in attendance, and it does not need royalty charges and shareholders profit to make the electric light a very costly luxury.

So much for the commercial aspect of the question. But I do not hesitate to say that if the figures had all been the reverse of what I have given you, I should entertain no fear as to the competition of the electric light for the following among many reasons:—

1. The impossibility of reducing it to a power generally useful.
2. That it does not admit of regulation.
3. It is so variable and uncertain that no space can be left wholly to the illumination of one lamp.
4. Its colour is more trying and wearying to the eyes.
5. The light must always require periodical attention on the part of the consumers.

In fact, so far as adaptation to the purposes of general, and especially of domestic, illumination goes, it appears to me that all the graver difficulties are as unconquered now as they were 20 years ago.

There is one aspect of the comparison between lighting by gas and by electricity which is worthy of remark, as explaining the magnitude of the plant that would be required by the latter. The electric light cannot be stored; consequently, the plant must be equal to producing the maximum amount required at the moment when it is wanted. A Gas Company with a capital of £1,000,000 are able to supply 1,000,000 cubic feet per hour at the time of greatest consumption. This is equal to a light of 3,200,000 sperm candles. I am safe in assuming that 1-horse power would not be equal to producing an electric light of more than 400 available candles. Now, dividing 400 into 3,200,000, we have 8000 as the equivalent in horse power of 1,000,000 cubic feet of gas. This power would need to be broken up into many sections, and would not cost for engines, boilers, houses, shafting, and machines, less than £80 per horse power; consequently, the 8000-horse power would cost £640,000. But then I have shown that, as compared with gas, not one-fourth of the effect of the electric light is actually obtained; consequently, because of the disadvantageous circumstances under which it is burned, at least four times as

much must be provided. If the £640,000 is multiplied by four, we have £2,560,000 as the cost of producing plant alone, exclusive of distribution, against £1,000,000 for gas, including all, and that estimate is not at all surprising, judged by the illustrations we have had opportunity of examining hitherto.

If I have occupied too much time by these remarks, I beg you to excuse me; I had no intention of dwelling so long on the subject when I commenced.

And now let me, in conclusion, say a few words suggested by the recent scare as to what, in my humble opinion, should be the future policy of Gas Companies.

Nothing has come more prominently to the front in the discussions which have taken place than the wonderful adaptability of gas to the various requirements of artificial illumination. We supply a light which is cheap, safe, pleasant, and unfailing, whether as a diminutive night-light or a brilliant glare. But further, with the same material, we can cook the delicate omelette to perfection, and the dinner for the million with economy. Gas, too, is a cheap and convenient motor, whether for driving a hairbrush, an electrical machine, or, to venture upon prophecy, a tramway car. It is also capable, without causing dirt or needing attention, of warming our houses in situations where otherwise warmth would be difficult or impossible of attainment. Then again we are manufacturers of other products which are the bases of important industries. The salts we produce are of such fertilizing power that they cause the desert to rejoice and blossom; while from another residual, among uses of a more prosaic but still profitable character, we are able to lend to beauty the glories of the rainbow. But it is not necessary that I should dilate upon the variety of our resources; suffice it to say, that we are alive to the fact, that every material formerly regarded as obnoxious is only so much matter out of place, and which may eventually be developed into an element of profit.

Now the question I would ask is the same in effect as that which was put with so much power and weighty argument by Mr. Bennett last year. Have we done full justice to this great inheritance? I do not think we have much need to be ashamed of the past, but we have certainly a large field before us which will amply repay the cultivation of it. We congratulate Mr. Warner that the step he initiated last year, and which was described by our Past-President (Mr. Spice) in language of glowing approval, has borne fruit beyond the limits of South Shields. Stockton has had an exhibition of gas apparatus and products of the gas manufacture, which "won golden opinions from all sorts of people;" and more recently Birmingham has opened its Town Hall to the reception and exhibition of such a collection of apparatus for the economical and convenient use of gas in its multifarious applications, as has never before been attempted. These exhibitions have been accompanied by what is of vital consequence to their use—viz., full information as to the *cost* at which the work shown is accomplished. These exhibitions are important strides in the right direction. What is wanted now is that they shall become, at least in all large towns, universal, and that they shall be *permanent*.

I commend to the attentive observation of all who visit Paris, the means adopted by the Paris Gas Company to educate the public in this way, both as to the use of gas and coke. I hope we may soon see similar establishments opened here, where consumers will be able to ascertain how best to use the commodity with which we supply them; for in this way a reproach will be lifted from us, and a great service rendered to the public.

Our true interest lies in so conducting our business that our position as monopolists is lost sight of. We should proceed upon the lines indicated by the successful tradesmen in active competition, who are ever ready to press the question, "Is there anything more that we can do for you?"

I have previously touched upon the relation which the charges due to excessive expenditure of capital bear to the selling price of gas. Permit me to point out what a reserve of security and usefulness we at present possess in this direction. We are all aware that gas-works must be planned and laid down, not relatively to the annual sale, but to the

greatest day demand; and our calculations would be imperfect if we failed to take into consideration the maximum hourly consumption; for mains which would be competent to distribute a day's make over six hours, would manifestly prove inadequate to pass the same quantity in five. But the shortened hours of labour of late years have limited the maximum rate of consumption in many towns, I am told, to little over two hours. Our plant, therefore, must be large enough to meet the strain of a few hours demand which is greatly in excess of that of the rest of the day, and, in summer time, some 70 per cent. of it may be said to be idle.

Now let me suppose a town where the selling price of gas is 3s. 6d., and the charge for dividend on capital, 1s.; we have thus 2s. 6d. per 1000 cubic feet as the cost of gas at the consumer's meter. Out of the 2s. 6d., it is reasonable to suppose that leakage, distribution charges, rates, and management will cost at least 8d. per 1000. Now the actual expenditure under all these heads would be practically the same if the sale of gas were doubled by a day consumption. I assume that distributing plant, including gasholders, represents one-half the capital account, and, consequently, one-half of the 1s. required for dividend. We have then 6d. for interest, and charges amounting to 8d., in all 14d. as costs not dependent upon annual consumption. Now, assume that the public have been made alive to the undoubted economy of gas for cooking, warming, &c., and that the consumption is thereby doubled by a day demand, clearly the 14d., which I have named, would, in that case, be divided by two, and gas could be sold for 7d. less, or 2s. 11d. against 3s. 6d. per 1000 cubic feet. Many Managers are fully alive to these considerations, and, I think, they are destined to have increasing weight. Let us here, in our Association, and at home in our individual spheres, lend our earnest attention to still further improving the quality, and cheapening the price of gas. Let us also educate our consumers into the proper use of it, and the future of our industry will be at least as bright as its immediate past.

Gentlemen, I have trespassed too long on your patience, accept my thanks for the kindness with which you have listened to me.

The PRESIDENT then announced the award of premiums for papers read last year, as follows:—No. 1, Mr. C. Woodall; No. 2, Mr. R. O. Patterson; No. 3, Mr. W. H. Bennett; No. 4, Mr. W. Sugg. He also stated the arrangements which had been made for the excursion to Hampton and to Paris, where, he said, French friends had made every effort to ensure a pleasant and interesting visit.

Messrs. Hartley and Darwin were appointed scrutineers of the ballot papers for the election of the Officers and Committee of the Association for the ensuing year.

READING OF PAPERS.

The reading of papers was then proceeded with.

BRICK, CONCRETE, AND COMPOSITE TANKS.

By Mr. W. Richards (London).

(Read by Mr. F. W. Hartley, on behalf of Mr. W. Richards, who was unable to be present.)

In the construction of gasholder-tanks, the first consideration is, of course, the stability of the ground, that the foundation shall be sufficiently solid, in order to sustain the weight of the tank, water, and holder, without settlement; but, as this is essential in every class of structure, further reference to it will not be made.

The other important points connected with my subject are—the nature of the building materials employed in the bulk of the work, whether these be brick, stone, shingle, gravel, or other similar substances. Also the means of uniting or cementing these materials together, either with hydraulic lime mortar, which possesses its hydraulic property in consequence of the lime containing a quantity of argil; or whether a purer lime be employed, and rendered hydraulic by an admixture of a substance such as Puzzolana; or by the employment of Portland or other cements. Lastly, we have to consider the proper means of employing these materials, which, as will be shown hereafter, constitute the most important of the operations in the construction of tanks.

It may be briefly stated that bricks, brick ballast, as well as some kinds of stone, are more or less porous; but how far this influences the proper construction of a tank I will have occasion to demonstrate. On the other hand, many kinds of stone, as well as shingle, the pebbles entering into the formation of gravel, and the grains of sand, so far as regards their impermeability, leave nothing to be desired. With these, therefore, the means of uniting them together with hydraulic mortar or cement is all that is requisite in order to form a tank, at least so far as regards the materials employed.

Respecting the mortars and cements, it may be observed that hydraulic limes can only be obtained in certain localities; and, as they are not sufficiently valuable to bear heavy expenses in carriage, for these reasons their use is limited. Puzzolana is comparatively little known in England, which is to be regretted, on account of its great value; indeed, such is this value, that when a small portion of Puzzolana is intermixed with good lime mortar, whether for concrete or other uses, the compound possesses nearly all the properties of Portland cement, except that it requires a longer time to set and harden. Moreover, as Puzzolana exists in the neighbourhood of Edinburgh, opportunities are afforded for its more general employment in the United Kingdom, which is further encouraged by its low price, and the small quantity required to be intermixed with the mortar in order to render it hydraulic.

There are various kinds of hydraulic cements, but that which experience has proved to be the best for our purpose is the Portland, and to which my observations will be principally confined.

Among the advantages this possesses are—its moderate price, that it can be mixed with two and even three times its volume of clean sand and still retain an extraordinary degree of tensile strength or cohesion, that in setting it neither contracts nor expands, and that it may be stored in barrels in a dry situation for many months without suffering any deterioration beyond the simple circumstance that it requires a somewhat longer period to set than if freshly made. But, whether recently manufactured or otherwise, or employed pure or intermixed with proper proportions of sand, this cement has the property of hardening, in the course of time, in a wonderful manner. In confirmation of this statement, I have only to refer to the pavement in some places in London, set therein, in which the

cement projects in polished ridges, while the stone adjoining is worn into deep recesses. But a still more striking fact is that paving stone is replaced with advantage by slabs formed of the cement in question, intermixed with sand; and such is the resemblance between the artificial and natural stone that to the uninitiated it is a matter of difficulty to distinguish between them. A few years ago, in a highly interesting paper, read before this Association by Mr. Douglas, that gentleman mentioned some of the advantages of Portland cement. Among these, he observed that a beam composed of it, of 4 inches square, and 14 inches long, on being fixed at one end, bore a weight of 1580 lbs. placed at the other end, thus possessing, as he observed, half the strength of Riga fir timber.

We find in some reference books that a definite degree of cohesion is stated to exist, in ordinary work, between the bricks and mortar, which is usually estimated at about 60 lbs. per square foot; but, to show the error of this, we find in observing houses in a state of demolition, in almost all cases the mortar is actually crumbling to dust, thus clearly proving that no material cohesion exists; and instead of the mortar hardening with time, as it certainly should, if properly prepared, the opposite is the fact, which arises from the indifferent kind of materials used in the first instance; but, as I shall have occasion to show, in order to produce sound work, as much depends on the manipulation as on the materials employed.

The accepted theory of the action of mortar is, that the hydrate of lime possesses a great affinity for the silica composing the sand intermixed therewith, and that in the course of time, by the lime absorbing the carbon from the carbonic acid existing in the atmosphere, it is again converted into the carbonate of lime, similar in nature to that it possessed prior to calcination, which is further assisted in acquiring the desired degree of hardness by the particles of silica in combination therewith. And undoubtedly, when due care is observed in the selection of the materials, particularly when the sand is granulated and clean, with good lime, in the course of time the mortar made with these acquires a stone-like hardness; but when mortar is prepared with loamy sand, or with certain earthy substances, it can neither possess any proper degree of cohesion, nor become hard, simply because the action of the lime is counteracted by the presence of the foreign pernicious substances.

As ocular demonstration is always more forcible than any verbal description, I have prepared a few specimens with Portland cement, in order to illustrate my arguments, which specimens were all made with the same description of cement, but under different circumstances. Thus No. 1 consists of six flat tiles, cemented together *when in a dry state*, which, after being allowed a considerable time to set, on the cement becoming hard, with a slight blow the tiles were easily detached; from which we learn that a very limited degree of cohesion exists between cement or mortar and bricks, stone, or other materials, when the latter are in a dry state.

Now, if the same description of tiles be thoroughly saturated with water at the instant of cementing, a very different result is obtained, as may be observed in specimen No. 2, in which the cement is so intimately incorporated with the other that the tiles actually break before becoming detached. Hence we find that, to obtain perfect cohesion, it is absolutely necessary that the bricks or other material shall be thoroughly saturated at the time of operating.

As a further trial of the adhesion of Portland cement, the specimen No. 3 was prepared. This is simply a cylinder of that material, of about 6 inches long and one square inch in sectional area, and at each end is placed a wire in the form of a hook or eye, which wire is enclosed for a short distance in the cement, and intended for the purpose of testing its cohesive strength. To this was suspended a weight of 112 lbs., without the cement breaking, and how much more it would bear I am unable to say, as I did not possess the facility of testing it; but, confining myself to this limit, and taking the specimen as a basis, we find that Portland cement has a cohesive force or tensile strength of 112 lbs. per square inch, or no less than upwards of seven tons on the square foot, which agrees approximately with the statement of

Mr. Douglas already referred to. But according to another statement by that gentleman in the communication mentioned, at the end of 30 days Portland cement possesses the extraordinary tensile strength of 417 lbs., and at the end of two years, 675 lbs. per square inch, or nearly 40 tons per square foot of surface. With this remarkable material at our command, it seems astonishing that the same thickness of walls of houses and tanks adopted many years ago should be still retained, and that Engineers do not avail themselves of the remarkable cohesive strength of Portland cement and other similar materials.

Now, speaking theoretically, and taking the strength of the specimen as a basis, the small tank No. 6, of a thickness of one inch, if made of pure cement, should bear the pressure of a column of water 200 feet high, and this without hooping, or any other external support, and a brick tank of one foot thick, supposing every care to be observed in its structure, would be more reliable than any cast-iron tank, with its bolts, nuts, flanges, and hoops. Briefly, in ordinary constructions, instead of proper importance being attached to the cohesive force of the mortar or cement, a thickness of wall or weight of material is brought to bear against the pressure of the water, which is further aided by the pressure of the ground on the exterior of the tank; but I venture to say that, if proper consideration is given to the cohesion of the cement or mortar, and ordinary care taken to ensure this, then the walls of tanks may be reduced to a considerable degree with a corresponding economy.

I now request your attention to composite tanks, which I believe were first constructed by Mr. V. Wyatt, and from which I will pass to those of concrete.

Originally the sides of composite tanks were formed by an inner and outer wall of brickwork of limited thickness, leaving an intervening annular space, which was gradually filled with concrete as the walls were carried up. Subsequently, improvements were introduced by dispensing with the outer wall, and in its place a moveable frame was adopted to retain the concrete until it became set.

But in neither of these constructions was the concrete intended to retain the water, but simply to give strength to the structure, and, as Mr. Wyatt observed on one occasion, he did not believe for one moment that concrete could be made water-tight, that he had built walls 10 feet thick, and yet the water came through like a sieve.

I may here observe that a system similar to the first mentioned is adopted in some parts of the Continent, for the formation of water and wine tanks—that is, by having an inner and outer wall of stone, with the intervening space filled with hydraulic concrete. When constructing these, in a wall 2 feet thick, with a space for the concrete of about 15 inches wide, the concrete is composed of stones, varying in size from a hen's egg to gravel, with an abundance of hydraulic mortar or cement in a liquid state; and, whenever a quantity of concrete is placed, a man is employed to probe it continually at the sides in order to eject the air, which would otherwise be formed in "pockets," as seen in specimen No. 5. The tanks made as described are often employed to contain wine, and in every respect are successful, and their impermeability is due entirely to the concrete; therefore, I ask, why cannot the same degree of excellence be attained with gasholder-tanks?

To resume my notice, a further progressive step was made by Mr. Douglas, by building a tank entirely of concrete, which he afterwards lined with brickwork, as he observed, "to gratify the eye." In the formation of this tank, the cement was not intended to hold the water, for, as Mr. Douglas said "it would leak like a colander," and so it undoubtedly would if not properly prepared.

The next important achievement to be noticed in the class of tanks under consideration was that erected at the South Metropolitan Gas-Works, in which not a single foot of stone—in the ordinary acceptation of the term—or a single brick, entered into its formation, the whole being constructed entirely of concrete, afterwards rendered on the interior with pure Portland cement; moreover, in the construction of this vessel, puddle was entirely dispensed with. The experiment was one of remarkable boldness on the part of Mr. Livesey, and, on the whole, was successful,

and that gentleman has done good service by showing the inutility of puddle, which at one time was considered indispensable, whatever it might cost. In this tank also the concrete was not relied on to retain water.

We now come to the consideration of the construction of tanks, and particularly in the formation of concrete, in which, as I will show, the cement unites the masses of shingle, or ballast, with a degree of success, both as regards cohesion and impermeability, depending entirely on the manner the operations are conducted. I must, however, express my diffidence in venturing assertions in opposition to universal practice, but as our desire is to acquire knowledge, and disseminate it, I am sure that if my remarks are soundly based on facts, the gentleman mentioned will be the first to recognize them at their proper value.

We see every day, in the formation of the foundation of roadways, and other work, the concrete is often prepared in the most careless manner, in which a portion of cement is thrown on the ballast, and on this being wetted, the mass is turned over two or three times, and is then placed in its position; but by these means at least one-half of the ballast never comes in contact with the cement, and it follows that, as *concrete*, that portion is useless, and, of course, prepared in that manner, it must be porous.

But, on the other hand, if the ballast be clean and well wetted, and a sufficiency of cement or mortar gauged or mixed with its proper quantity of water, then, on combining the ballast and cement, and turning them over several times, the cement will percolate throughout the mass, so that no interstices exist; consequently, on setting, the concrete becomes impermeable, and in three or four weeks attains that degree of hardness, that on applying a hammer and chisel the stones frequently split before becoming detached.

A popular error is the opinion that Portland cement, like some others, is injured by the slightest excess of water. This, however, is not correct, as concrete formed with it can be thrown into shallow water, without any material deterioration beyond the small quantity of cement which may be washed out in the operation.

To illustrate an imperfect method of making concrete, specimen No. 4 was prepared with loamy gravel in a dry condition, intermixed with one-third its volume of cement. This breaks with facility, clearly showing that the strength of concrete is impaired by employing dirty concrete, and any carelessness in its preparation. With the same kind of material, and under conditions similar to those observed in making the last specimen, the tank No. 5 was made, and, as you may satisfy yourselves, this system of construction, in the double sense of the term, "will not hold water."

For the purpose of illustrating the means of constructing concrete tanks in a superior manner and impermeable, the specimen No. 6 was made with all ordinary care with clean granulated sand, well wetted, and intermixed with the gauged cement, as already indicated, the materials being in the same proportions as No. 5. This is filled with water, and, as may be observed, it is completely water-tight without the aid of rendering, or any other means, beyond simply placing the material in a mould. In the absence of the proper appliances, the specimens are very rudely made, the principal object being to present to your notice the effects of different manipulations, and, above all, to prove that concrete can be prepared in such a manner as to be impermeable.

Blocks 7 and 8 were also made in a similar manner as the tank No. 6, the strength and impermeability of which are evident.

Therefore we find that the nature of concrete, both as regards strength and impermeability, depends on the manner it is prepared; and, by the proper admixture of the cement with the ballast, each stone or pebble or piece of brick, is surrounded with the cement, which adheres with the tenacity already stated. But, in the event of an insufficiency of cement, or the presence of dirt, in the first instance, a number of cells are left, through which the water percolates, and, in the latter case, the dirt impairs the action of the cement; and, in the course of time, the former is washed out, leaving a passage for the water. Lastly, as shown, when the brick or stone is not well wetted at the time of working, but little cohesion exists. As already stated, Portland cement hardens with time, and thus a

properly constructed tank would, in the course of one or two years, attain the hardness of hard stone; whereas, with indifferent materials, instead of hardening, the reverse is the case, when both strength and impermeability are sacrificed.

And here I may observe, that it may be objected that, in consequence of the limited dimensions of the model (if it may be so termed), it is not exposed to the same pressure as an ordinary tank; but, on the other hand, it should be remembered that it is only 1 inch thick, and, if a comparison be made with large tanks of 40 or 50 feet deep, having their walls 4 or 5 feet thick, if this be duly calculated, it will be found, at least so far as regards their respective dimensions, that the smaller vessel is the more difficult to render impermeable.

With regard to the large proportion of cement employed, this, of course, is necessitated by the smallness of the pebbles and sand; but when ballast is employed varying in size from a hen's egg (or in extensive work still larger stones can be employed) to ordinary gravel, then the quantity of cement will be very materially diminished, and, in some cases, 1-20th part of cement will be sufficient—that is, one yard of cement will be sufficient for 20 yards of concrete.

From the preceding statements, and the specimens before you, we learn that where bricks are laid in a dry state, that, notwithstanding the cement may be of the best, no material cohesion exists between them. But when the bricks are thoroughly saturated with water at the instant of laying them, an incredible degree of cohesion is obtained, and it is to be regretted that advantage is not more generally taken of this property.

We also learn that the strength and impermeability of concrete tanks is mainly dependent on the manipulation, and that if any loam or dirt exists with the sand, or if the ballast be not thoroughly combined with an abundance of cement to fill all the interstices, that a structure of this kind cannot be relied on. But if only ordinary care be observed, concrete can be rendered impermeable for the construction of tanks, and it follows that whenever ballast is available at a cheap rate, concrete tanks may be made with a considerable degree of economy, of course, dependent on the relative prices of ballast and bricks.

Hence, as ballast can be incorporated with cement to form a sound tank, it is evident that brickwork and masonry can be applied with like success. With these, each brick or stone will be required to be embedded in the cement, and to ensure the proper cohesion, it cannot be repeated too often, both should be saturated at the time of working.

I have attempted to explain the extraordinary strength of Portland cement, and to prove that tanks can be constructed without the aid of puddle, and, indeed, in most places on the Continent, that material is not known, and, of course, is not adopted; yet, sound tanks of brick and masonry are to be found in abundance. Puddle was employed in the earliest years of gas lighting, long before Portland cement was discovered; and it would not be creditable to the present generation if they persisted in following the methods introduced 50 years ago, and particularly when such vast advantages are gained, on the score of economy, by the introduction of a more perfect and scientific mode of constructing gasholder-tanks.

Mr. G. Anderson said he would describe a work in which he had been engaged, as bearing upon the question dealt with in the paper just read. He had had a tank to build for gas-works, where the bottom of the ground was a peat bog, the peat lying at an angle of about 30° to the surface of the ground. He could not go down to the level of the peat, and therefore decided to float the tank on the bog, and to build it of concrete in the manner Mr. Livesey had recommended, without a single brick or any masonry. He first dug a vertical channel 9 feet wide all round on the site of the tank, into which he put a bed of concrete, 3 feet thick and 9 feet wide, with a skew back to the face of it. He then put his walls on the back of the concrete. He commenced by putting a layer of timber under the concrete, and began at the side where the turf was deepest, and there made the wall 6 feet higher than at the other side, expecting that it would

sink more. After having finished the walls, his next object was to take out the interior, and he intended to form a bottom in the shape of a frustum of a sphere, so that it should be able to support the internal pressure. He feared, however, that the great thrust of this on the walls might split them, and therefore put into the concrete three strong iron hoops, about 5 inches broad by 5-8ths of an inch thick. The first year he only built the walls, and did not form the bottom, but put the materials of which it was to be constructed on the top of the walls, so as to load them, and cause them to sink as much as possible. During that winter they sunk 6 inches lower on one side than the other, and he had to restore the level by putting in more concrete. In doing so, he made the lower side 2 inches higher, expecting that it would still go down again. It not only did that, but sank 2 inches more; in fact, it sank about 15 inches on one side and 10 inches on the other during the course of the year in which it was erected. During the whole of that time, however, it never cracked, and it was now as tight as any tank he ever saw; so much so, indeed, that it overflowed with every shower of rain. The whole of the tank was rendered with cement.

Mr. SMITH (Darlington) asked Mr. Anderson whether the wall kept plumb when it sank 15 inches on one side and 10 inches on the other, and, if so, how it was there was no crack.

Mr. ANDERSON said it did not keep plumb, the whole thing went over slightly as a solid mass. It necessarily went out of plumb, in sinking, perhaps one-half or three-quarters of an inch, and the guide-bars were set accordingly.

Mr. GEORGE LIVESEY (London) said he had listened with great interest to the paper just read, but there were one or two points in which he thought it would be advisable to be somewhat careful. For instance, with regard to the tenacity of cement. According to his experience, it would not do to rely on that to prevent a tank cracking. His tank, to which reference had been made, was 45 feet deep, and 184 feet in diameter. When filled with water to about 30 feet of the top, it remained sound for some months, while the gasholder was being put in; but when it was entirely filled, five or six small cracks took place. Now, if the concrete was possessed of such enormous tenacity as was represented, it was rather astonishing that a thick wall should crack from the top to the bottom with no apparent force to produce such an effect. One would think that it would go off like the report of a gun; but, on the contrary, it seemed as if it parted with perfect ease, and as if there was no tenacity whatever in it. The cracks opened to the extent of about 1-16th of an inch, running from the top nearly to the bottom, and almost vertically, right through the concrete, causing a slight leakage. He had, therefore, come to the conclusion that it was necessary to take extraordinary precautions to back up or support the concrete where puddle was not used. Where puddle was used, the concrete or brickwork was in perfect equilibrium, the puddle being the thing which held the water, whilst the concrete or brickwork held the puddle in its place. Where, however, concrete was employed, and rendered with cement, it was important that it should be thoroughly supported to resist the pressure, the whole of which was exerted on the thin skin of rendering. Unfortunately, the pressure came at a time when the tank was least able to stand it—just after the tank had been constructed, within six or nine months, when the concrete had not had time to harden and develop its full tenacity. The same difficulty had been experienced in France. He had seen a report in the JOURNAL OF GAS LIGHTING, some time back, of a French tank built of concrete, which had cracked in the same way. That tank was backed up with sand, solidly as they thought, but still not with sufficient solidity to prevent all expansion of the concrete, and the result was that it cracked or opened. Water was allowed to pass behind it, and thus its equilibrium was restored. He should be inclined, although he objected to it some time ago, to put iron bands into the concrete, especially in the upper part, where the wall was thinner and the backing was not so solid, to resist any strain which might be put upon it when first built. He had certainly not lost his faith in concrete, but he did not say it was to be used everywhere. If he had no gravel at hand, and bricks

were cheap, he should use them, and in like manner he should not dispense with puddle if he were constructing a tank in clay. Where there was no clay, where bricks were dear, and materials for concrete were cheap, there was no question which was the right course to pursue. He did not like puddle at all, and, wherever it was possible, should avoid using it, for he had had a great deal more trouble with puddled tanks than with concrete ones. There was one error in the paper just read which he ought to correct—namely, where it was stated that Mr. Wyatt was the first to construct composite tanks. That was not so; the composite tanks for the Chartered Company were not decided upon until Mr. Docwra showed Mr. Evans the plans of one to be constructed at the South Metropolitan Works on the composite plan. The Chartered Company then decided upon it, though they were thinking of it before. With regard to concrete, any material almost might be used, provided it was clean and free from loam. One of the best things to mix was the useless clinkers from the furnaces. They mixed well with the concrete, and all descriptions of cement had a hold on them which they hardly had on any other materials. These clinkers, therefore, instead of being a drug, might become of great use where building operations were going on.

Mr. PATERSON (Cheltenham) said he understood from the paper that the writer did not approve of the ordinary method of mixing concrete in the dry form, but advised that the cement should be mixed with water, and poured over the ballast. That was rather important; but he should never think of doing it in that way.

Mr. HARTLEY said that was only with reference to certain tanks made abroad for wine.

Mr. LIVESEY said he was not so much interested in wine tanks as in those of a different description. He understood that Mr. Richards recommended that the ballast should be wetted first, and then the cement applied, but not in a liquid state. That was certainly contrary to all his experience in the matter. The rule was to turn over the materials twice by hand, dry, then to mix the water, and turn over again twice. They also had a further mixing from being put into the barrows and deposited in position. Cement certainly could not be properly mixed with ballast if it were wetted in the first instance.

Mr. HARTLEY said what Mr. Richards laid more stress on was the wetting of bricks or stone—bricks especially.

Mr. H. GORE (London) said that, having had some experience in the use of concrete, there was one matter which appeared to him to deserve some notice. He understood the writer of the paper to recommend mixing Puzzolana with lime; but he (Mr. Gore) found it was dangerous to use it, especially for a water-retaining tank when in contact with lime. It was to all intents and purposes a volcanic cement, due to the decomposition of certain matter, and when it was used with lime, and exposed to the action of water, after a time it underwent a fresh decomposition; the lime apparently extracted the cementing material, and the tank constructed with the composition became, to a certain extent, a colander. He might say that time was one of the most important elements in judging of the practicability of using concrete. His own experience had been that concrete which required the greatest time to become perfectly solid was that on which the greatest reliance could be placed as to the ultimate result, and this was only a natural consequence, bearing in mind what took place. In the mixing of concrete, certain materials were taken and surrounded with a substance which underwent some chemical change; in this process the water took a new form, entered into combination with these materials, and in proportion as that recrystallization took place, so would perfect cementation result. Therefore the longer time that could be allowed for the process, the more perfect would be the result. The experiments referred to entirely bore out that view. It was shown that if a number of dry bricks were put together with cement, crystalline action did not go on, simply because there was no permeation of the water of crystallization with the minute particles of cementing material; but if the brick was immersed in water, all its pores were in a condition to absorb the cement, and thus the effect was produced which was so essential for a permanent solid tank.

Mr. H. P. STEPHENSON (London) remarked that his experience in the use of Puzzolana differed entirely from that mentioned by Mr. Gore. When engaged, many years ago, on the Sunderland Dock, he used it very largely indeed, and found that it became as hard as a stone. It was used in connection with blue lias lime and sand, and the mortar to the present day stood as well as the day after it was set. On the general question, he thought Mr. Livesey had summed up the matter very carefully, with one omission—namely, that concrete tanks ought to be carried out by very careful workmen, and under a very careful Engineer. If these points were attended to, they might be safely adopted.

Mr. HUNTER (Salford) wished to say one word to justify a work in which he was himself engaged. He understood the writer of the paper to regret that Engineers of the present day were still following the lines of 50 years ago in the mode of constructing tanks, and to express an opinion that the antiquated method of building them with bricks and puddle ought no longer to be continued. He (Mr. Hunter) was at present constructing a very large tank on that old-fashioned plan, simply because, while he altogether agreed with what had been said about concrete, he could, under the circumstances in which he was placed, build a brick and puddled tank much cheaper than if he used concrete, because he was building upon a bed of clay.

Mr. WARNER (South Shields) said that at the mouth of the Tyne immense quantities of concrete blocks were manufactured, generally measuring about 10 by 6 by 4 feet. The arrangement in use there was to employ, in the construction of these blocks, a cylinder with two sides cut off, which cylinder was hung by a travelling crane above the moulds, into which the concrete was allowed to fall. The materials were placed in the cylinder, and four men, by means of a winch-handle, turned it round so many times, and then opened a door, through which it fell into the mould. He had used a similar arrangement for some time; but, instead of a winch-handle, he placed a drum on the cylinder, round which a rope was wound, and a horse attached to it, so that the motion of the horse rotated the cylinder.

Mr. MEAD (Sutton) said that when Mr. G. Livesey read his paper, some time ago, on concrete tanks, he stated, in answer to the writer, that he preferred the old-fashioned practice of puddling. Since then he had had some experience with a concrete tank, 102 feet in diameter, built something on the same kind of site as that described by Mr. Anderson, being on the side of a hill, and on very bad boggy ground. The Engineer who designed it, endeavoured to support it by building some strong piers against the weak side of the tank, but soon after it was built the water managed to get underneath, and came through at the rate of 3 feet in 24 hours. That mischief was remedied, and the tank filled again, but the next thing that happened was that it cracked close by the side of the pier, the crack descending to 5 feet from the bottom, which allowed the water gradually to run away to that level. On a former occasion he had stated his objections to building iron hoops into concrete, because he thought they would expand and crack the concrete, and he then suggested that a hoop round the outside would be the better plan. He was now going to try that, and, if successful, he would state the result at the next meeting. He believed that if the tank referred to had been built on the old-fashioned plan, it would be sound now.

Mr. HUNT (Birmingham) said he gathered that Mr. Livesey attributed the cracks in his concrete tank to the water pressing on the inside. He should like to ask him what depth below the coping the cracks occurred, and whether he estimated the pressure caused by the water inside as against the pressure on the outside of the wall. It was important to ascertain whether it was really the pressure which caused these cracks, or the shrinking of the concrete from imperfect mixture.

Mr. LIVESEY said he felt no doubt it was the pressure of the water. He calculated it, and found that, unless the backing was very solid indeed, cracks might be expected to take place. The backing was formed of solid sand, well rammed, but, solid as it was, there was just sufficient elasticity to allow the tank to give a little, which resulted in the cracks. They were

very slight, and no inconvenience arose, but still there they were, running from top to bottom.

Mr. H. Veevers (Bolton) said he had constructed a large tank 142 feet in diameter and 32 feet deep, without puddle, without cement, and without sand. He did not use cement, because he preferred hydraulic lime, ground with clinkers from the furnaces. It seemed to be the fact that hydraulic lime got stronger the longer it was left, whereas cement stopped at a certain point, when it took the formation of stone, and if it cracked, it would crack like stone. To avoid the walls cracking, he was careful to back up the brickwork with gravel thoroughly soaked with water. He was much struck with the remark of Mr. Stephenson that a concrete tank required very great care, because he did not think it required any more care than a puddled tank. If a puddled tank leaked in the slightest degree, there was a tendency for the puddle to get washed away, and the hole to get larger; but in the case of a cement or hydraulic lime tank, the fissure would get blocked up, and would not be aggravated by constant washing away.

Mr. Hartley, in reply to previous speakers, said he was sure Mr. Richards would be pleased to find what an interesting discussion his paper had given rise to. The substance of the paper was that, in making concrete tanks, great care should be exercised in the mixing of the materials and in the construction. He thought Mr. Hunter was under some misapprehension as to the signification of the expression used, and that the writer did not intend any reflection on Engineers who used puddle, but rather suggested that, in many cases, Portland cement might be used with advantage, and puddle dispensed with.

The President said he had been sometimes struck with the fact that year by year the same matters were brought up for discussion at the meetings of the Association, and did not seem to be definitely settled. This appeared to be the case this year, inasmuch as the remarks made by Mr. Livesey pointed clearly to the fact that in some situations one system might be the very best possible, whilst it would be utterly inapplicable in another. As to constructing a tank without puddle, he should like to repeat the opinion he had already expressed more than once, that where puddle was to be had at all it was very undesirable to omit it. In the case of the cracks referred to, as appearing in concrete, he thought they were more likely to be due to a slight contraction which took place in the drying, than to the pressure exerted by the water. He said this with great deference, but he founded it on this fact, that observing the walls of the Victoria Docks extension recently, he found that although they were of great thickness—22 feet or 23 feet—yet at about every 100 yards there regularly occurred a crack from the front to the back throughout the mass, although there was no pressure upon them whatever. This must clearly have been due to some slight contraction in the body of the concrete, and for this reason he thought that, in the construction of tanks, where puddle was to be obtained, it was desirable to use it. The things to be opposed to each other were brick and concrete, or puddle and rendering, and he perfectly agreed with Mr. Stephenson that it was necessary, where concrete was used—especially where layer came on layer—to exercise the most minute and careful attention to the work in its progress. There was one point mentioned in the paper which was well worth the time devoted to it—namely, the necessity for saturating the materials with which the work was done, whether bricks or ballast, for making concrete thoroughly with water before they were incorporated together.

TRANSFER OF GAS-WORKS.

By Mr. Alfred Penny (London).

It may possibly be considered that the subject of the paper now about to be read is somewhat foreign to the main objects of this Society, but the matter has of late assumed such large proportions, and the transfer of gas undertakings to Local Authorities has been of such frequent occurrence, that it has been considered by the Council to be a fit subject for discussion by the members of this Association.

It may fairly be asked, why should an industrial undertaking, such as the manufacture and sale of gas, which has been established by private individuals, for the supply of a public want, at their own cost and risk, be subject to interruption and control by Public Authorities of any kind? The answer is, that the distribution of gas involves an interference with the Queen's highway, and a breaking up of streets and pavements, which cannot be done legally without the authority of Parliament; and, although many small Companies carry on their operations without statutory powers, it is well understood that this is done at considerable risk and disadvantage to the Gas Company, if, as frequently happens, any differences should arise between them and the Local Authority of the district.

It is worthy of remark that there are but few instances of a Public Authority having established gas-works for themselves, Manchester being one of the few towns that have done so.

As a matter of history, it is well known that when gas lighting was first introduced into England, the profits upon the capital invested were generally very small, and sometimes absolutely *nil*.

At that time, therefore, no disposition was felt by Local Authorities to acquire the gas undertakings supplying their districts, and it was only when these undertakings began to be profitable, that the possession of them was coveted by the public bodies, who had, as a rule, done nothing to aid or assist them in their early struggles.

As the value of gas as an artificial light became more fully appreciated, and its use extended, the returns upon the capital invested increased in a like ratio, and gas undertakings began to take rank as a solid and permanent investment for capital.

Then commenced the attacks upon Gas Companies whose operations had become sufficiently prosperous to tempt the cupidity of Local Authorities.

These attacks took various forms; sometimes it was a clamour about price, sometimes about quality, and an alleged insufficient supply; but it invariably led up to the real object, which was a desire to become the owners of a profitable undertaking.

Fortunately, this object could not be attained without the assistance and consent of Parliament, who very early made it understood that they would lend no countenance to schemes which involved something like a confiscation of vested rights.

Many attempts were made to acquire gas undertakings compulsorily, but all ended in failure; and whenever Parliament were asked to confer upon Local Authorities statutory powers to acquire and hold a gas undertaking, or to erect works in competition, these powers were never granted until after they had agreed to purchase, at its commercial value, the undertaking of the Gas Company whose district they desired to supply.

The plea put forward in justification of these attempts was the public good, it being contended that the supply of gas ought to be in the hands of Public Authorities, because its distribution involved interference with the roads and streets, which were under the control of the said authorities; and that the profit made by the Gas Companies, and divided among their

Shareholders, ought to be made available to pay for public improvements, or to diminish rates.

It was also contended that after a Company had succeeded in making a profit sufficient to pay their maximum dividends, that they had no longer any motive for economical working, and that to avoid reducing the price of gas, and for the purpose of employing capital, they would make unprofitable extensions, and also pay large salaries to their managers and *employés*.

This is a fair sample of the allegations made against Gas Companies by Local Authorities when attempting to get possession of their undertaking.

It will be, I think, quite unnecessary for me to deal with these statements at any length; but having had a tolerably large experience in the examination and dissection of Gas Companies accounts—sometimes in rating cases, sometimes in connection with applications to Parliament for statutory powers, and also as the professional adviser of many Gas Companies—I am enabled to say that these statements are, as a rule, incorrect, and not capable of proof.

My own experience is that, however prosperous a Company may be, the Directors invariably use their best exertions to buy everything required for the purposes of the Company at the lowest possible rate, and certainly, as a body, they have not exposed themselves to the charge of paying their officers too liberally; on the contrary, it is my deliberate opinion that they too often err in the opposite direction, and, having regard to the positions of trust and responsibility held by the Managers of gas-works, they are, as a rule, insufficiently remunerated for the valuable services they render, and there is, consequently, no saving that can be made by public bodies in either of the above cases.

The one solitary advantage a Public Body would have over a Company would be in the lower rate at which they would raise money for the extension of the undertaking, as compared with the authorized dividends of the Company upon their share capital; but, as I shall presently show, even this has ceased to exist.

It is, perhaps, fair to state that the transfer of gas-works in some large towns has been precipitated, if not actually brought about, by the dissentions of rival Companies, and the disregard of true economical principles exhibited by them in the conduct of their undertakings; and, notwithstanding the *ad captandum* argument that competition *must* be of advantage to the consumers of gas, the public were not slow to perceive that a duplication of main-pipes through every street, with the attendant annoyance and cost caused by breaking up the roads, besides the expense of a double staff, with rival Boards of Directors, &c., could not, in the long run, be to their advantage.

In some of these cases the Companies concerned were wise enough to amalgamate; but in others, where party feeling was too strong, legislative pressure was brought to bear upon them, and the undertakings passed into the hands of the Local Authorities.

This state of things has, however, long ceased to exist, as Parliament has permanently recognized the fact, that it is for the true interests of the public that Gas Companies should *not* be allowed to compete with each other; but should, in the interests of the public, be placed under proper legislative restrictions, and become, in fact, regulated monopolies.

By the recognition of these principles, and by agreeing to abandon competition, and by districting their respective undertakings in 1860, the great London Companies have been enabled to hold their own, and to bid defiance to all attempts of the Public Authorities of the Metropolis to take from them the conduct of their various undertakings.

I will now speak of the effects of modern legislation upon the interests of Gas Companies, as bearing upon the question of the transfer of gas undertakings to Local Authorities.

By section 56 of the Companies Clauses Consolidation Act, 1845, a Gas Company having, under the powers of a special Act, raised capital partly by shares and partly by loans, were entitled, with the consent of the Shareholders, to create additional shares at par, and to pay off the loans—to turn their borrowed money into share capital.

This valuable privilege has now been withdrawn from Gas Companies, as Lord Redesdale insists upon a special clause being inserted in every Gas Bill, which prohibits any such dealing with that portion of the capital authorized to be raised by loans, except on the condition that shares so created should bear a dividend of not more than 5 per cent.

And by clause 58 of the same Act, any new shares created under the powers of the special Act of the Company were "to be apportioned amongst the then Shareholders in proportion to the existing shares held by them respectively."

I need hardly state that this is now a thing of the past. The Standing Orders of last session, which made it compulsory upon all Gas Companies applying to Parliament, either for a new special Act of Incorporation, or for additional powers, to insert what are known as the "auction clauses" in their Bills, have withdrawn from statutory Companies one of their most valuable rights.

The concurrent introduction of a standard price and a sliding scale is doubtless some alleviation; but, in practice, I think it will be found that but few Companies will be in a position to avail themselves of its advantages.

The effect of all this is, in my judgment, to take from the Shareholders of Gas Companies all pecuniary interest in the future extension of their operations.

We will now turn to the Gas Works Clauses Act, 1847.

By section 80 a limitation of 10 per cent. per annum is placed upon the profit allowed to be divided by the Company upon their original paid-up share capital.

Section 81 is of so much importance for my argument, that I make no apology for transcribing it entire:—

"If the clear profits of an undertaking in any year amount to a larger sum than is sufficient, after making up the deficiency in the dividends of any previous year as aforesaid, to make a dividend at the prescribed rate, the excess beyond the sum necessary for such purpose shall from time to time be invested in Government or other securities; and the dividends and interest arising from such securities shall also be invested in the same or like securities, in order that the same may accumulate at compound interest until the fund so formed amounts to the prescribed sum, or if no sum be prescribed a sum equal to one-tenth of the nominal capital of the undertakers, which sum shall form a reserve-fund to answer any deficiency which may at any time happen in the amount of divisible profits, or to meet any extraordinary claim or demand which may at any time arise against the undertakers; and if such fund be at any time reduced, it may thereafter be again restored to the said sum, and so from time to time as often as such reduction shall happen."

Section 83 provides that when the reserve-fund is full, the interest thereon shall be dealt with as part of the profits of the undertaking.

Section 84 provides that the reserve-fund may be used to supplement the profits in any year where sufficient has not been earned to provide the prescribed rate of dividend.

Section 85 provides that if there be any profit in excess of what is required to pay the prescribed dividend, and if the whole of the reserve-fund has been, and remains, invested, that the price of gas shall then be reduced, &c.

It is quite clear, from the above, that the establishment of a reserve-fund has been sanctioned, if not prescribed, by the Legislature, and that all Gas Companies, with statutory powers, are entitled, if they think proper, to fill up their reserve-fund *before reducing the price of gas.*

In practice, however, this is not commonly done, and very few Companies have any reserve-fund at all within the meaning of the Act—*i.e.*, *properly invested.* In most cases, undivided profits are invested in extensions of the works and plant, and are made to do the work of capital to the great benefit of the consumers.

But having regard to the fact that circumstances may arise at any time which may make it advisable or necessary for a Gas Company to part with their undertaking to a Local Authority, I wish to point out that it is the interest of all Gas Companies, before unduly reducing the price of

gas, to fill up their reserve-funds, to have their plant in the highest state of efficiency, and to keep their accounts in the clearest manner.

It is useless to attempt to hide the fact that, from various causes, the control of gas and water works is passing into the hands of public bodies, and it is well that the matter be looked at full in the face, that all parties should understand how their interests will be affected, and how those interests may be best protected.

By the introduction of "auction clauses" into all Gas Bills, and the extinction thereby of the rights of Shareholders to take new capital at par, their interest in maintaining possession of their undertakings has been sensibly weakened, and, consequently, there is no reason to suppose that the process of "transfer," which has already assumed such formidable proportions, will have less force in the future than it has had in the past.

So far as the interests are concerned of the gentlemen whom I have now the honour to address, I fear they may not be better off under the new *régime* than under the existing one, but it is possible that the gas consumers may find themselves anything but benefited by the change.

The result of many recent arbitrations to settle the value of gas undertakings has been conclusively to show that a Gas Company, earning full statutory dividends, will obtain not less than 25 years purchase of same; in other words, that the purchasing body will be able only to get 4 per cent. upon the purchase-money of the existing business.

In some recent cases of transfer, where there has been an invested reserve-fund, it has been, by arrangement, retained by the sellers, and as the ambition of the Local Authority purchasing is usually to show a large profit on the working of the concern, the experience in the past has been that this result is arrived at, for the most part, by maintaining the price of gas at a higher level than would have been possible, or necessary, if the undertaking had remained in the hands of a Company controlled in their operations by section 35 of the Gas-Works Clauses Act, the restrictions contained in which have never yet been imposed upon a public body having authority to supply gas, who are at liberty to make any profit they can, so long as they charge no higher price for gas than the maximum price named in their Act, or in that of the Company of whose undertaking they have become possessed.

It is quite clear, therefore, that gas consumers may, by this means, be taxed for the benefit of those ratepayers who are not gas consumers.

The foregoing observations are principally directed to the case of those Gas Companies having statutory powers; but there are many instances of Local Boards, in growing districts, attempting to acquire the control of the gas supply in their respective localities, where the Gas Company are not protected by a special Act.

I need hardly point out that in such cases the non-statutory Company are at a great disadvantage, and, in fact, have no option but at once to go to Parliament for an Act of Incorporation, because, under the powers of the Public Health Act, 1875, section 161, any Urban Authority, where there is no company or person *authorised by Parliament* to supply gas for public or private purposes, may themselves undertake the supply of gas throughout the whole or any part of their district; that is to say, a non-statutory Company whose operations are not protected by a special Act or by a Provisional Order, confirmed by Parliament, are very much at the mercy of the Local Authority desiring to acquire the gas undertaking.

Very exaggerated notions of the burthens which the cost of an Act would entail upon a small Company prevail, but experience has shown that the benefits far outweigh the cost.

There are numerous Companies, with a sale of from 6 to 12 millions, without statutory powers. If a Special Act costs say £800, taking the sale of the smaller quantity, the cost of the Act would only entail an additional charge of about 1¼d. per 1000 cubic feet, and for the larger quantity about ¾d., while the possession of the Act will not only be a source of strength in dealing with the Local Authority—the operations being protected by Statute—but will absolutely enhance the value of the undertaking for sale, to a greater extent than the sum expended in obtaining it.

I therefore strongly advise small Companies *without* statutory powers seriously to consider this question in connection with the subject of pro-

bable or possible transfers in the future, and to protect their property in the way I have indicated.

I will now bring this paper to a close, and while I am quite sensible that the information it contains is already well known to many gentlemen now present, yet there are doubtless others to whom it may be useful.

I have no other motive in bringing before the meeting the subject of this paper except that I may add my mite to the mass of valuable information which has been gradually accumulating since this Association has been established, and will only say, in conclusion, that whether the gas-works of Great Britain remain in the hands of private companies, or pass into the possession of public bodies, it is quite certain that there will never be a lack of able and honourable men, with the necessary scientific knowledge and skill, to carry them on with advantage to the public and credit to themselves.

Mr. H. P. STEPHENSON said it was very curious that in the parliamentary arrangements made with regard to Gas Companies, the authorities were very careful that in Gas Companies Bills stringent clauses should be inserted, defining very exactly the powers conferred; but when public bodies themselves went to Parliament they never said anything whatever about these things. They seemed to think they were such virtuous, honest individuals that all these matters might be left to their own honour. What struck him in connection with the paper just read was this—that, if some small Companies went to Parliament to get an Act, with a view to afterwards transferring their undertakings to the Local Authorities, they might have such disagreeable provisions included in their Acts that the Local Authorities would not have anything whatever to do with them.

Mr. SHEPPARD (Horsham) said there was one point which might affect the interest of many members present. It would be found in the Public Health Act that, when a Local Governing Body purchased a statutory Company, they were required to make remuneration to the officers. He would, therefore, suggest to those present, if they happened to belong to non-statutory Companies, that they should use every endeavour to induce their Directors and Shareholders to get incorporated.

Mr. STORER (Stafford) desired to thank Mr. Penny for his admirable paper, and only regretted that it had not been read several years ago. Had it been, it would have given information to many Gas Managers, which would have proved very useful to them. Had his Company possessed the information some few years ago which he had been in possession of some few months, the Stafford Gas-Works would never have been transferred to the Corporation at the price they were, although the price obtained was nearly 30 years purchase of the dividend; and it was a compulsory sale too, which was about as high a price as that of any gas-works which had been transferred. Looking at the tendency of things in the present day, he would advise his brethren to put their houses in order, and have all the apparatus connected with their works thoroughly up to the mark; to let everything be done as well as it possibly could be done; to fill up the reserve-fund; and, amongst other things, if the Corporation had not already an Act by which they had power to purchase the works, to carefully watch that Act when it was being obtained. The Act at Stafford, under which the Corporation obtained the power, was unfortunately not watched. He would not say whose fault it was, because the party was not present; the consequence was, a clause was inserted which was never noticed until about a week ago, the effect of which was that the whole of the purchase-money must be equally and rateably divided amongst the Shareholders, without any provision being made for the compensation of Directors or officers. The transfer did not take place without going to arbitration. Some of the most eminent men of the day examined the works, and under the arbitration certain awards were made. Amongst other things, were certain sums allotted for the Secretary and for Directors; but he was sorry to say that, in consequence of the clause mentioned, all those allowances had vanished, and the Directors found themselves obliged to pay over every penny of the purchase-money to the Shareholders.

Fortunately it was discovered that the Company had not paid their full dividends for a certain time, and they were able to capitalize the interest on the debenture stock which had been borrowed at from 4½ to 8 per cent., or else they would have been handed over, tied hand and foot, at 25 years purchase.

Mr. CARR (Halifax) rather regretted the tone that some of these discussions took with regard to Corporations. He had made a similar remark at the last meeting, and as so many Members of the Association now represented Corporations, it was only fair that some one should take the Corporation side in these questions. He for one thought a great deal more was said about Corporations than was altogether justified. Of course, there were some Corporations whom no one admired, and, judging by the way in which some Companies rewarded their servants, none of them would like to be in similar institutions. But he had had experience of some Companies who did not do exactly as they ought to do, or as they considered a Company ought to do, just as there were some Corporations who did not exactly do what they would like. It struck him that if the Members of the Association were to follow out the President's suggestion, and make a report to their respective committees when they went back, and had to state that the meeting had been engaged in pitching into Corporations, and showing them up in the most deplorable light, these bodies might be induced to reconsider the question whether they would allow their Engineers to come to these meetings. He was quite certain that many of these reports got into the hands of Corporations, and he could not think that the members of those bodies who read them would be favourably impressed by what they read as coming from the mouths of their servants when they assembled together. Some gentlemen objected to his remarks, but he was not speaking so much about anything which had been said that day, but was rather drawing a strong case of what he desired to avoid. He thought they should try to make the Association as representative as possible, not of gas companies, but of the engineering profession; and he was sorry to see that the JOURNAL OF GAS LIGHTING took a one-sided view of this matter—even going the length of questioning whether any man of honour could serve a Corporation. He thought those remarks were to be deplored. They did not improve the position of those gentlemen who did serve Corporations, and he was quite sure they did harm.

The PRESIDENT, interposing, said the discussion of remarks which appeared in the JOURNAL OF GAS LIGHTING was hardly pertinent to the question.

Mr. CARR said he would, of course, bow to the decision of the Chairman. There were one or two remarks in the paper which seemed to him rather contradictory. One was that Gas Companies invariably did the best they could, independent of any pecuniary benefit it might be to the consumers. Then, in deploring the action of auction clauses, Mr. Penny went on to say that the effect was to take away any pecuniary benefit the Company might have from the proper regulation of their business. These two things did not go very well together. He was not exactly of the opinion expressed with regard to the auction clauses. He thought 10 per cent. was a very high sum to be guaranteed by Parliament as the return for money *to be* invested, though it was not at all too high for money which had been invested under risks which did not now exist. Seeing that the risks had all been removed by Parliament, he did not see that so high an interest was required for money which had to be invested in future.

Mr. HELPS (Bath) said they must all be thankful to Mr. Penny for his interesting paper regarding the transfer of gas-works to Corporations. He would suggest that some member should read a paper next year on the other side of the question—namely, the transfer of gas-works from Corporations to Companies.

Mr. WOODALL (Leeds) said he had occupied for some time the exceptional position of being in favour of the transfer of gas-works to Corporations. At Leeds the Corporation were doing all that any Company could be supposed to do in the interest of the gas consumer, and the line of policy they pursued was the very opposite to that which Corporations ordinarily followed. When he went to Leeds he found a deficit of something like

£20,000, due from the gas undertaking to the borough fund, and until they had paid that, the Corporation did not feel justified in dealing with the profits as belonging to the consumers. But that amount once paid off, he propounded the principle of "gas profits for gas consumers," and, somewhat to his surprise, he had very little difficulty in permeating the whole Corporation with his view on the subject. From that time the Committee had gone to the extreme in that direction. They did not even wait for a balance in order to be assured that they might sell gas at a lower price in the year following, but they anticipated the balance which was to accrue, supposing the price were maintained, and he had his instructions each year to prepare an estimate in such a way that no balance should remain. In fact, it would be best work on his part to make the income and expenditure exactly balance, and not allow of one penny being paid even for income-tax. But while he favoured this principle of the transfer to Corporations, he did not see that much good could result to any parties, now that auction clauses were introduced into all new Acts, because under the auction clauses, a Company would in future erect additional works at a cost of 5 per cent., whereas a Corporation must pay 4, or 4¼, or perhaps 4¾ per cent. for money they required to raise; and they must put by, for a sinking-fund, perhaps 1 per cent., so that the charge for the future gas business of Corporations would be quite as large as if the business were managed by Companies.

Mr. PENNY said there was not a great deal to reply to. Mr. Woodall had made some apposite remarks; but he thought the line of conduct adopted by the Corporation of Leeds was an exception to the rule. His own opinion was that, when Local Authorities acquired gas-works, they did it with a view of obtaining profits for some general purpose. No doubt the idea was that it would be a benefit to the township; but as it happened, the profits so obtained were provided by the gas consumers, so that those who were not gas consumers received a benefit they were not entitled to. However this might be, he did not consider that his observations on Local Authorities and Corporations were obnoxious to the remarks made by Mr. Carr. This gentleman overlooked the fact that Local Authorities first attacked Gas Companies, with a view to get possession of their property. He (Mr. Penny) had certainly not said much to the detriment of Corporations in respect of their conduct of gas undertakings; but, all the same, he believed their management was not superior to that of the Companies whom they superseded, nor did he think, if his paper were read carefully, it would be considered by Corporations that their officers had been placed in a false or improper position by merely listening to its contents. What Mr. Storer had said was much to the point—viz., that it was necessary for Gas Companies, and those who advised them, to be very careful in the conduct of their operations, having regard to what might possibly happen. The mischief in Mr. Storer's particular case was done long before the arbitration commenced, and could not be undone by those acting for the Company at the time the arbitration was being held. So far as he could gather, those whose duty it was to watch the Stafford Corporation Bill watched it at a distance, and so did not see those obnoxious clauses which bore so hardly on the officers of the Stafford Gas Company. There was no doubt that when a Gas Company were about to be transferred, it was advisible, if possible, that the interests of those who had been serving them so many years should be studied. He should, therefore, strongly recommend the Directors and Officers of Gas Companies, when a transfer of their undertaking was in contemplation, not to wait until the mischief was done, but at once consult those competent to advise them, who were constantly engaged in parliamentary business, and knew what the meaning of those little clauses were, which appeared simple in themselves, but which sometimes had very serious consequences when they came to be inquired into and acted upon.

The PRESIDENT, in closing the discussion, said he was quite sure the whole body of members would have supported Mr. Carr in the observations he had made, but he was not aware that, either in the present discussion or any other when he had been present, anything had been uttered to which exception could be taken.

CAPITAL AND REVENUE.

By Mr. George Livesey (London).

"The Proportionate Capacity of Apparatus and Standards for Capital and Expenditure" is one of the suggested titles for a paper, and although it appears a very practical subject, it will probably be found, on further consideration, an exceedingly difficult one to deal with satisfactorily. The first part, relating to the proportionate capacity of apparatus, would probably be answered in the best manner if a return could be obtained from a sufficient number of the members of the Association to be fully representative of all the varied circumstances under which gas undertakings exist, setting forth the capacity and the cost of construction of the retort-houses, condensers, washers, scrubbers, purifiers, gasholders, and mains. An individual can give only his own experience, which certainly could not be accepted as a reliable standard for all gas-works, seeing that no two can be exactly alike.

In reference to capital, which is the chief subject of this paper, it ought to be possible to find a maximum standard, in proportion to gas-producing power, which shall be capable of application to all except the smallest works.

The relation of capital to revenue is, in principle, a simple matter, but in our business it is complicated by such a variety of circumstances and interests that a great confusion of opinion and of practice has resulted.

Capital may be defined as money represented by productive works, or used in working a business; there is a vast amount of so-called capital which is unfortunately represented by nothing at all. To begin with, we have the National Debt, which represents nothing but the good faith of the country, and its ability to pay, not its debt, but merely the interest; but the debt is not capital representing actual property. Again, there is an enormous amount which goes by the name of capital, although it stands for nothing but money spent in fruitless contests, in waste of various kinds, mistakes and extravagance on works that are obsolete or worn out, and on works that now have no existence.

This does not apply to gas-works merely, but to railways, docks, water-works, and to joint-stock enterprises generally. So long as a concern is able to pay interest on its nominal capital, it is assumed that the capital is represented, and it has a market value; but I hold that the only sound position is that the works and plant should be fully worth, at all times, the sum charged against them in the capital account. It is quite true that capital may, nay, must be expended, and with perfect fairness on other things than plant. For instance, the cost of an Act of Parliament, or the *legitimate* expenses attending the starting of an undertaking, or the amount paid for a foreign concession, are all proper charges on capital; but a sinking-fund must be provided out of revenue to liquidate the cost of the concession by the time that it expires. Preliminary expenses also should be written off as soon as possible, and even the cost of an Act of Parliament. Although the powers conferred by it may be exceedingly valuable, present and prospective, still, changes being possible that may render an Act of Parliament valueless, the capital account should be cleared of this charge also, in order ultimately to attain the position of having every penny of capital fully represented by the structural value of productive works.

This may be said to be a mere truism, and in the case of the individual millowner, manufacturer, or shipowner, it must be accepted and acted upon, or he will sooner or later find himself in difficulties. The principle is recognized and put into practice by the great Steamship Companies, and there is, I suppose, at least one English Gas Company, whose works are

all on the Continent, and one or two Companies with works in England, where the value of the plant *exceeds* the amount of the paid-up capital. But these are exceptional cases, and not recommended for imitation; they are sacrificing, to some extent, the interests of the existing Shareholders for the benefit of posterity, or for the public body that may purchase their undertaking. They have, however, as yet, found scarcely any imitators, the overwhelming majority erring in the opposite direction at the expense of future generations of Shareholders or of the Public Authorities who may be tempted to purchase.

In many cases the disparity between the value of the works and the interest-bearing capital would, if the business were not of an exceptional character, be simply ruinous. Where would an ordinary manufacturer, exposed to fair competition, find himself if his plant for making a certain article had cost just double as much as other makers had expended on similar plant? The question needs no answer.

Having made the statement that gas undertakings generally have a larger capital than is represented by works, it is necessary to bring evidence in support of it, and to name a standard of capital in proportion to gas-producing power that shall be fairly applicable to all ordinary cases, and allow a good margin for unforeseen contingencies. The margin will be somewhat greater in large works, but not so much greater as would appear at first sight. For instance, a retort-house to enclose ten retorts would probably cost less in proportion to the number of the retorts than one to cover 200, seeing that the walls of the small house will be less than half the height and thickness of the large one, and the roof also will cost less. On the other hand, small gasholders cost more in proportion than large ones.

Four years ago, in this room, I said that the capital expenditure on new plant might, in most cases, be kept within £5 per ton of coals used in the year. I am now prepared to say that where the capital exceeds £5 per ton, or, say, 11s. per 1000 feet of gas sold, the capital is greater than the value of the works, mains, and working capital. It is better, perhaps, to take as the unit the 1000 feet sold, rather than the ton of coals used; but if we assume that the unaccounted-for gas does not exceed 10 per cent.—it should be well within that figure—the ton of coals will stand for 9000 feet of gas sold. These terms are easily convertible by dividing the amount per ton by nine; and so, for convenience and simplicity, I shall take the ton of coals as the unit.

Of the total capital, if a Company pay all their accounts in cash when the goods are delivered, nearly 10 per cent., but not exceeding that amount, will be required for working capital; this leaves £4 10s. per ton for plant. It is generally agreed that of the capital expended, about two-thirds will be laid out on the works and land, and one-third on mains, meters, and services. By this rule we obtain out of the £5—

Works per ton of coal	£3	0	0
Mains, &c., outside the works	1	10	0
Working capital	0	10	0
Total	£5	0	0

Or at per 1000 feet sold it will be—

Works	£0	6	8
Mains, &c.	0	3	4
Working capital, about	0	1	0
Total	£0	11	0

This statement is based on my own experience in the construction and valuation of works. It is supported by that of eminent engineers with whose work I have become acquainted, who have exceeded in economy, without sacrificing efficiency, anything that I have done.

The item of £1 10s. per ton, or 3s. 4d. per 1000 feet sold, for the outside plant, does not require detailed evidence to prove its sufficiency. I, therefore, proceed to sustain my assertion that £3 per ton, or 6s. 8d. per 1000

feet sold, as applied to the cost of works and land is sufficient, by the following actual cases, the names only being withheld.

It is not contended that the capital account should be exactly divided as above indicated. All that I wish to maintain is, that the £5 per ton, or 11s. per 1000 feet sold, is a sufficient maximum capital for all but very small works.

Case No. 1.—Small works in Yorkshire, complete in every respect, and capable—with a margin of at least 15 per cent. of retorts out of use in the depth of winter—of carbonizing 16 tons of coals per day, or 8200 per annum—say, 8000 tons—which, with a total cost of works and land of £8420, gives £2 16s. per ton of coal, or 6s. 8d. per 1000 feet sold.

Case No. 2.—New works on new site, to replace old worn-out works in a cheap district—North of England. The Company with a heavy capital, and very little to show for it, necessitating great economy. With a little correction, these works can be taken as capable of using 100 tons of coals per day, or 20,000 tons per year; but taking them as constructed, there is a retort-house, to contain retorts sufficient to carbonize 125 tons per day, and to allow more than 10 per cent. out of use. Condensers, exhausters, purifiers, scrubbers, and meter for 100 tons, or 1,000,000 feet per day. Gasholder storeage, 500,000 feet. Cost, inclusive of six acres of land complete, £28,600. Coals used in the year, 9000 tons, equal to £2 12s. 5d. of capital per ton of coal, or 4s. 9d. per 1000 feet sold.

But, by adding another gasholder for 500,000 feet, and setting some additional retorts, the capacity of the works will be brought up to 100 tons per day, or 20,000 tons per year. For these additional works, I add, as the outside cost, £11,000, which is more than they would amount to at the rates at which the other work was executed.

The total, therefore, for 20,000 tons per year will be £34,600, equal to £1 14s. 7d. of capital for each ton of coal used in the year, or less than 4s. per 1000 feet sold.

Case No. 3.—Some entirely new works, not 100 miles from this place, erected as an additional station for a large Company, calculated to make 3,000,000 a day, corresponding with a consumption of 60,000 tons of coals per annum. Cost complete, with a large plot of land, very little over £100,000, or well within £2 per ton of coal, or 4s. 6d. per 1000 sold.

It is right to add that cases 1 and 2 are in cheap districts, No. 1 being erected at the time when prices were rising, No. 2 in cheap times, and case No. 3 is not in a cheap district; but the work was done, and done thoroughly well, when prices were low.

Case No. 4 is that of a large Company where a large area of land was purchased, some ten or twelve years ago, adjoining the works on which the extensions have been made. This Company have, I know, charged to capital, during the past 12 or 15 years, a sufficient sum to pay for all the outlay on land, works, mains, meters, &c., to meet the requirements of a business that rather more than doubles every ten years, with the result that the proportion of capital to coals used has remained stationary at about £4 15s. of capital to the ton of coal. At the same time the price charged for gas by this Company has, during the whole period, been lower than any of their neighbours. A very large proportion of the additional work was executed during those late years of excessive prices, and the surplus power of the works has been very considerably increased. The gasholder capacity, in 1866, was less than 80 per cent. of the maximum make, and in 1877 it was 115 per cent., while the retort power, with the other portions of the plant, has been increased to a corresponding extent beyond the proportions of ten or twelve years ago.

I do not say that the cost of the works, as set forth in cases 1, 2, and 3, is to be taken as a standard, for I consider that any standard should be based on average prices and circumstances; but these cases, taken in conjunction with case No. 4, fully warrant me in saying that £5 per ton, or 11s. per 1000 feet sold, is a sum that ought not, in any case, for new works, except the very smallest, to be exceeded. Whether or not it is necessary or desirable in all cases to make the effort to reduce existing capitals to this level is not my business to decide. It is a complicated question, and must be settled by those immediately concerned. I only say that any capital exceeding this standard is not represented by works.

That capitals generally exceed this limit is an undoubted fact; but, in order not to appear invidious, I take the London Companies as an example.

In 1861, when the first parliamentary return was made, the aggregate capital of the 13 London Companies was £5,647,899, and the coals used did not exceed, but nearly approached to 644,000 tons. I cannot obtain exact figures, but know that this may be taken as sufficiently correct. This works out to close upon £9 of capital per ton.

In 1869 the capital, share and loan, amounted to £7,828,844, and the coals to 1,171,588 tons, which gives £6 13s. 8d. per ton, the highest amount of capital being £8 7s. 4d., and the lowest £4 10s. 6d., three of the 13 Companies being below the £5 standard.

This shows a very great and commendable improvement, and it shows, moreover, what may be done in the reduction of capital.

In 1877, another interval of eight years, we find only six Companies. The total capital amounted to £11,845,749, and the coals used to 1,814,246 tons, or £7 6s. 11d. per ton, the highest being £8 0s. 2d., and the lowest £4 15s. 8d., only one of the three Companies, with capitals below £5 per ton, being left, the other two having been amalgamated.

During this last interval, a great increase has taken place in the capital account of some of the Companies, while that of others has been very considerably reduced. The increase is accounted for by the gigantic works that have been erected, and has, therefore, to some extent, been unavoidable; but it ought to be reduced from year to year, as these works come more and more into use.

Notwithstanding all these variations in the capitals, the course of the Companies has been one of almost uniform prosperity, and the question naturally arises, How is it that these undertakings should be so prosperous? Either the principle laid down in this paper is altogether wrong, or there is something extraordinary in the circumstances under which Gas Companies exist.

Some will at once say that it is all owing to the absence of competition, which is, in a sense, correct; but if the inquiry is carried somewhat further, it will be found that the defective legislation, which has been brought to bear on the Companies from outside, by those who wished to exercise control over them, has the most to answer for.

The legislation controlling Gas Companies was framed in the days when competition was universal. I refer to the general Act of 1847, which was, for those circumstances, an exceedingly good and just Act, both for the public and the Companies; but when the circumstances had entirely changed, by the complete abolition of competition, this Act, in its relation to capital and dividend, became obsolete. This the Authorities did not see, and in the Metropolis Gas Act, 1860, they incorporated and reaffirmed, with some slight limitations as to back dividends, the 1847 Act. That it was a great mistake is, I consider, amply proved by the widespread and almost continual discontent which the public authorities have shown since 1860 towards the London Gas Companies, which dissatisfaction has been reflected in the provinces, resulting in endless inquiries in Parliament, which produced, after a three years contest, the Act of 1868, providing a power of revision. The notorious revision clauses utterly failed to give satisfaction; the discontent they produced leading to another protracted inquiry, which led, in 1875–6, to the adoption of the principle of the sliding scale, advocated by the writer before this Association in 1874. This was, at the time, vehemently opposed by the Companies, who allowed the right opportunity for its adoption to pass; but, after twelve months consideration, they effected a treaty of peace with the Authorities on that basis, and were compelled to accept the auction clauses, which I did not recommend, and, as a Gas Shareholder, do not like, but against which I cannot argue, for I consider them a just arrangement under the circumstances of non-competition in which Gas Companies are placed.

So far the sliding scale has worked satisfactorily; the public have not grumbled, but have rather commended the increased dividend that has, in one or two instances, been paid in London. I hope and believe that the Companies—who now express their satisfaction with the sliding scale—if bad times come, necessitating a reduction of dividend, will cheerfully

acquiesce, for it is simple justice that producer and consumer should share in fair proportions the advantages of prosperity and losses of adversity.

The old legislation designed for competition, but continued after it was abolished, made it difficult to do right, and easy to do wrong in reference to capital; but now there is no excuse, thanks to the valuable tables compiled annually by Mr. Field, to legislation on sound principles, and to the light thrown on the question by the numerous public inquiries into the matter.

There is, however, ample justification for the excessive capitals of the Companies. *They* did not create the legislation, it was forced upon them by Parliament; *they* did not create a state of competition, it was forced upon them, in most, if not all cases, by the Consumers; therefore the Companies cannot be blamed for the natural result of Acts not their own, nor for reducing their capital by extending their works out of revenue.

Lest the advocates for competition should think that a return to it would be beneficial, let me say that it was the cause of a greater amount of waste and loss, both on capital and revenue account, than any other circumstance affecting Gas Companies—a waste and loss which ultimately fell upon the Consumer, and to this objection to competition must be added the immense public inconvenience that resulted from the multiplication of mains in the streets. Competition is utterly out of the question; it is a system most expensive to the Consumer, while it is ruinous to the Gas Company.

There is, however, one serious objection to a small capital. In these days, when scarcely a week passes without a report of a Gas Company having been purchased by the Local Authority, which fate stares all the rest in the face, it is but natural that the question of a reduction of capital should be looked at in reference to its effect on the probable terms of purchase. It is the fact that, with purchase in view, it is a positive and great disadvantage to a Company to reduce their capital. The rule is, not to take as the basis of purchase the intrinsic value of the concern, but only the amount of dividends paid. I will put a hypothetical case:

Company No. 1 sell 100 millions a year, and have for this purpose the moderate capital of, say, £50,000 (a trifle below the standard of £5 per ton); they divide amongst shareholders, at 10 per cent., £5000 a year, and the price they would receive from a purchasing authority would be, at 25 years purchase, £125,000.

Company No. 2 also sell 100 millions, but have the extravagant capital of £100,000, or nearly £10 per ton of coal; the dividend amounts to £10,000 a year at 10 per cent., for which they would receive £250,000, or double the amount of No. 1, or even if half the capital was at 7 per cent. they would then receive as dividend £8500, and as purchase-money £212,500, against £125,000 in the other case.

Where is the justice of this, and how can any Gas Company be expected to exercise such a high standard of exalted virtue as to reduce their capital when purchase on this system is in view? It may be thought that my illustration is much exaggerated, but such is not the case. A transfer has just been effected under the following circumstances:—The Company's able Manager has for years been working with the view to reduce the capital to a thoroughly sound basis, and has succeeded in bringing it well within the £5 limit, and in getting in addition a large excess of plant. The Counsel employed to conduct the case before the Arbitrators was unable to secure more than the usual terms, although if the capital account had been run up to £7 or £8 per ton, the Shareholders would have received half as much again for the very same property.

What, then, is to be done? Parliament has, in a measure, caused, and has undoubtedly sanctioned, the past expenditure on capital. It may be wise to reduce this, and it is quite fair to effect the reduction out of revenue, but as to future expenditure on capital account there ought to be no doubt.

Capital may be lost by the construction of more expensive works than are necessary; and that there is a tendency in this direction there can be no doubt. Human nature likes grand things, and Committees of Town Councils, with the rates, as they say, behind them, as well as Boards of Directors, are not free from this infirmity. They are frequently

carried away by an imposing appearance, when something much more simple and less expensive, while equally good, would answer the purpose. Contractors and Manufacturers naturally throw their influence into the scale in favour of expensive plant, and I can find no fault with them for doing so, except with those who find in it a larger margin for the exercise of the bribery to which some of them owe a large portion of their business, as one who signed himself a "Commission Abolitionist," in a letter he addressed to *The Times*, confessed that he had made his business, to a great extent, by this system, and then endeavoured anonymously to kick over the ladder by which he had mounted to prosperity, and at the same time to destroy the reputations of all connected with gas-works.

Engineers and Managers also have a laudable desire to make their works as substantial and good-looking as possible; but this often leads to loss of capital in needlessly expensive constructions. I do not by any means advocate anything paltry or shabby, but I believe that gas-works that are soundly, but not too substantially, constructed, well proportioned, and with an evident fitness for the purpose for which they are intended, without any direct attempt at ornamentation, and with economy apparent in every feature, will look when in use, and the dirt and smoke have had time to take effect, infinitely better than those highly ornate constructions that have such a fascination for some people. To my mind, this high art, as it may be styled, is out of place in gas-works, which, when placed in a suitable position, are scarcely ever seen, and, if seen, are not likely to be admired, except when quite new and clean.

Let it, then, be our object to produce the greatest effect with the smallest expenditure. A lavish expenditure may, in one sense, be a benefit to some, but economy and care on the part of each or any section of the community is the only way to create lasting prosperity.

A word as to revenue. In these times, when all traders are complaining, gas undertakings still find their revenue maintained. It is, however, their duty to make a right use of it; they are, in fact, bound, by the common bond of duty to the community, to exercise care and judgment in the appropriation of revenue; and to us, as Gas Managers, it is highly important that we should give our attention to this question as well as to that of capital.

Taking the gross revenue, which we will assume is carefully collected, and that the most has been made of all the sources from which it is derived, the first charge upon it is to pay for the materials and labour required in the ordinary working of the business; the second is the annual expenditure of so much of it as is sufficient to maintain the works and plant in thorough good order at the full capital value. Where portions of the plant have become obsolete or worn out, they should be renewed out of revenue, and in cases where apparatus of increased size is erected to replace that which is used up, only the cost of the additional gas-producing power should be charged to capital, the rest being borne by revenue. It seems almost waste of time to insist on such a self-evident principle, but it is necessary, because it is a very common practice to charge the whole cost of renewals to capital, and where new works are erected this is almost the universal rule. I suppose because the value or the original cost of the abandoned works is too great to be taken from revenue in any year; but where this is the case, a sinking-fund ought to be established, writing off from revenue a fixed sum yearly until the whole is liquidated in a reasonable time. It should be remembered that after the new works are erected, the charge for repairs for some years will be merely nominal; it would therefore be fair and right to charge against revenue the full normal amount for repair and maintenance, and thus reduce the capital by writing off something every year; or, if this cannot be done, by paying the cost of additional plant and extensions from revenue.

In the appropriation of revenue for the maintenance of works, there would be no difficulty if a fixed and certain sum each year were required; but it sometimes happens that a very large sum is required in a single year, as, for instance, when a gasholder has to be renewed, or a large gasholder must be erected in the place of a smaller one. The renewal is a charge that should be entirely borne by revenue, and, in the other case, out of the total cost of the gasholder, so much should be charged to

revenue as will represent the original value of the small holder. Supposing a small holder cost £3000, and in its place a larger one is erected, costing £10,000, of this sum £7000 is chargeable to capital, and £3000 to revenue.

Unfortunately, the various Acts of Parliament provide no depreciation-fund for meeting such cases; consequently, it very commonly happens that the whole £10,000 is charged to capital, thus making the accounts show £13,000 as the amount expended on this gasholder, while it is only worth £10,000. The creation of a suspense account, to liquidate the £3000, would, under these circumstances, be a proper thing to do. Anything, in fact, being better than to allow the £3000 to stand as part of the capital, with nothing to show for it; but suspense accounts should, if possible, be avoided.

The Gas-Works Clauses Acts provide that, after paying full dividends, and filling up the reserve-fund, all further profits shall go to the consumers, in the shape of a reduction in the price of gas, overlooking entirely the necessity for a depreciation-fund, or a maintenance-fund, which should be the first object of attention.

The only suggestion I am able to make is that, after filling up the reserve-fund, a moderate surplus should be gradually accumulated and carried forward from year to year as an undivided balance. I do not think any objection could be taken to this course, provided the balance did not assume unreasonable proportions. That an objection would be taken is most unlikely, seeing that any action by the Authorities, under the Act of 1847, is rarely, if ever, undertaken to compel a reduction of price. Such action against such a fund, accumulated honestly for the purpose herein indicated, would now be far less likely than before, seeing that recent legislation leaves the undivided balance perfectly free. I could give instances where the undivided balance has been of the greatest benefit to both Companies and Consumers, providing a fund for the former out of which to meet any extraordinary charge, which must otherwise have been met by an increase in the price of gas. I say, therefore, provide such a fund in advance, out of which to pay the charges for abnormal repairs.

The last charge upon revenue is the dividend. The expenditure on the ordinary working, together with that on repairs and on the sinking-fund, when necessary, having been deducted from the gross revenue, the balance only, whatever that may be, is available for dividend, any remainder going to form a reserve-fund. If the principles enunciated here are acted upon, there will be but little fear that, under any conceivable circumstances, the net revenue will be insufficient for this purpose, but I can conceive circumstances in which, if sound principles are neglected in prosperous times, the dividends may not only be seriously reduced, but destroyed. We have no right, because circumstances are in our favour, to neglect those principles on which alone a sound business can be founded; those principles must be maintained against mere expediency, and they will, in the end, be found to work the greatest good for the greatest number.

In conclusion, I must ask you to forgive any apparent dogmatism in this paper. I have no desire whatever to force my opinions upon you, although, when called upon, I am bound to express them. If they are unsound, I shall be glad if you will refute them; but if they are right, I hope they will be generally adopted, and that, in adopting them, increased prosperity may result to the Members of the British Association of Gas Managers.

Mr. Gore, as one who had suffered very considerably from what he believed was a misconception of the very important question now brought forward—namely, the relative proportion that capital ought to bear to works constructed for the manufacture of gas, wished to give a few words from his own experience and observation. For many years it was the custom to debit capital with all the expense connected with the promotion, construction, and completion of gas-works, and for many years it was considered that that capital was entitled to receive its maximum dividend. A clause in the Gas-Works Clauses Act of 1847 was looked upon as a clause which gave Shareholders an indubitable

right to 10 per cent. on all the capital they had expended. The effect of reading the clause in that way, and the influence it had on gas property, was this, that there had been a disposition on the part of those who were connected with profitable gas-works to increase their investments in all directions, and no one could wonder that such was the case. It was the best investment in the country at the time, and gave the best guaranteed return on that capital; therefore, it was only natural that Shareholders should do their utmost to enlarge so profitable an investment. But what was the effect on Members of the Association —the men from whose brains must come that which enabled the capital to be made productive, and who were, therefore, deeply interested in seeing how the capital was expended? He need not ask the question, how much anxiety gentlemen had to pass through in order to meet that pressing demand for 10 per cent. on capital? If the capital had been reduced to such a point as would approximate to that which the works demanded, how much less anxiety would they have had in producing the return on that capital? Need he ask how many works there were whose working capital was not yet represented, to the extent of one-half, by the plant which was now in operation?—how much of it had been totally destroyed? He could refer to many works, and he almost thought he could point out one to which Mr. Livesey had alluded, where the original capital had been entirely destroyed, and new capital created; and yet the Manager was expected to pay a dividend on that double amount. Then there was another point of view of equal importance. Mr. Livesey had told them plainly that in this country they were accustomed to work with an unnecessarily large amount of capital. It had been his lot to visit a great number of works in various parts of the world, and he had been enabled to contrast the works constructed, not only in this country, but in many of the principal foreign cities, with those constructed essentially on what he might call British principles. He had seen works which fulfilled all necessary requirements, with all the retorts and plant economically in operation, at a reduction, in some instances, of 40, 50, or even 60 per cent. on the capital required for those constructed under the English *régime*. The facility with which capital was obtained in this country for the construction of works abroad had had this result, that Companies had burdened themselves with capital which, at the present time, did not show anything like the return it ought to do. He would take a case with which he was personally connected. They had the works constructed abroad, upon what he might call cheap principles, but which enabled them to supply the district economically and advantageously. The capital was, in round numbers, £40,000, and on that capital for eight years they had paid on an average 19¼ per cent. An English Company, established on English plans, with a plant only capable of making something like 10 million cubic feet a year more than their own, cost, as the balance-sheet showed, £118,000. Now, it was quite evident that, if the Manager of those works had been placed in competition with his, his 19¼ would appear a large return compared with about 6½ or 6¾ per cent. return from the other. He had in his mind's eye two or three concerns which he saw a few years ago in South America, where capital at least 40 or 50 per cent. more than it ought to have been had been expended in the works, and very naturally there was not a proportionate return. Gas Managers, therefore, had a great interest in keeping down capital. He believed the auction clauses objectionable, although they might appear to have a tendency in the right direction, provided they could inoculate Shareholders with common sense principles—namely, that if Managers and Engineers were to put their brains and intellect into their work, they should have the benefit. They had progressed within the last 50 years enormously. They carried on a business second, either in interest or domestic value, to no process carried on in the country.

Mr. H. P. Stephenson said he had no doubt the principle enunciated by Mr. Livesey, that all renewals, or partial renewals, should come out of revenue, was sound; but when a great amount of work fell in one year, it came hard upon a Company. The great difficulty he saw in meeting all the expenditure that might come in one year was that the profits might

be depreciated in that half year. Mr. Livesey suggested a sinking-fund; but how did he propose that should be carried out? and was it possible, in the present state of legislation to have such a fund?

Mr. Mead (Sutton) thought they were much indebted to Mr. Livesey for his valuable paper. The figures he gave applied, as stated, more especially to large works than small works; and he must say that his experience had been limited to comparatively small works, with capitals from about £3000 to £300,000; and the difference between the capital necessarily expended in the establishment of those works was very great indeed. He put it, not as Mr. Livesey did, in tons of coal carbonized, for he did not think that was the most convenient form, but rather in thousands of feet of gas sold. In some works a much larger quantity of coal might be carbonized than elsewhere, although not so much gas was paid for; therefore, he based his calculations on the number of thousands of cubic feet of gas sold. He found that the capital averaged from about 16s. and upwards per 1000 cubic feet of gas sold. He was sorry to say he had lately joined a Board in which the capital expended was 34s. per 1000 feet sold. He did not mean to justify that at all, for there was evidently a large sum of money wasted. If the works were increased as the business extended, he agreed that all old plant disued should be compensated for out of revenue. He knew in former days, even at the works where the President was now Engineer, things had gone in a different direction. If he recollected rightly, when Mr. Livesey, sen., took the management of the South Metropolitan works, they were something like £80,000 to the bad. The Engineer was an extravagant man, and had spent, no doubt, too much, and, in order to pay good dividends, charged a great deal to capital that very properly belonged to revenue. It was a question what was fair to do. Supposing, for argument sake, that £1 per 1000 feet, or £1000 per 1,000,000 feet, would be a very fair sum for gas-works, there might be two Managers, one not quite so careful as the other; the one would buy a great number of things out of revenue, and so reduce the capital, until at last, as in the South Metropolitan Company, they would have a capital of something like 10s. 7d. per 1000 feet sold. In their case 1s. per 1000 feet would pay 10 per cent. on the capital all round; but with £1 of capital per 1000 feet it took 2s. to pay 10 per cent. How far, then, was it fair to now go on paying out of revenue certain sums which ought properly to come out of capital—he meant fair to other Companies, who had not the opportunity of doing so? The effect would be this—that one Company, in a very favourable situation, might earn full statutory dividends, and yet place a large sum out of revenue to capital account, by paying for things that ought properly to come out of capital. The result would be that one Company, say, at Plymouth, sold gas at 2s. 6d. per 1000, the other Company who had but acted fairly, not only to their Shareholders, but also to Consumers—for the Consumers for the time being had to make up this difference, whatever it was; and if a Company were spending out of revenue what they ought to spend out of capital, the Consumers for the time being had to find the money, though, ultimately, the succeeding Consumers had the benefit—could not afford to sell under 4s. The public said, "At Plymouth the gas is 2s. 6d.; why do you charge 4s.?" It had that damaging effect on other Companies. He thought the right principle was this—You ought to pay for all damage to your property, replacement of gasholders, and so on, out of revenue. If you turned out one holder, containing 100,000 feet, and put in one for 200,000, the one replaced ought to be charged to revenue. There should be a suspense account, and if too much was spent in renewal of property this year, more than could reasonably be paid for out of revenue by means of the suspense account, as much might be cleared off as could be afforded this year, and the balance next and the year after. But even this might be carried too far; and it was carried too far when the capital was reduced below what would be a fair sum for the construction of the works.

Mr. George E. Stevenson (Peterborough) said it appeared to him this question was one that required most careful consideration, and that it was one very difficult to decide upon. It was very difficult sometimes to ascertain the circumstances under which Gas Companies arose. It was somewhat easy to lay down a rule by which new gas-works should be con-

structed, but to say that the capital of any special Gas Company ought not to exceed so much, and that if it was more it was too high, was an arbitrary process which no one was justified in adopting, unless he thoroughly knew the circumstances under which the Company were constituted. For instance, his own Company was one which might easily be misinterpreted. It was a small Company, formed as late as 1868. Previously to that the gas-works were the property of a private individual, who managed his affairs on the most economical principle possible, for he never repaired anything. The consequence was the works fell into such a state of disrepair and incapacity that he was quite unable to supply gas, and unwilling to extend his supply. The consumers of the town of Peterborough, therefore, decided to go to Parliament to form a Company, which they did, and received powers to purchase the works of this private individual. They had to give for those small works, which produced, at that time, about 20 million feet a year, £30,000, and of that £30,000, not one shilling was represented at the present day in the Peterborough Gas-Works, because the whole of the apparatus was utterly useless, and had to be pulled down and new works constructed. That £30,000 saddled the small Gas Company at Peterborough with such a large amount of capital in proportion to the present make, that anybody seeing it at first would hold up his hands in astonishment. From the time the old works were purchased the most economical principles had been observed, and since that time a contingent-fund had been formed, and added to year by year, to which all unusual outlay, in the way of reinstatement, was charged. In most cases it was immensely difficult to attain to that point at which it could be said that capital was proportionate to the make of gas, and to charge a reasonable price, because the capital must necessarily bear its dividend, and Directors and Shareholders were not willing to lose their dividend for the sake of reducing the price. It appeared to him also that it was questionable whether it would be desirable, in such a case as that, or even one less remarkable, to deduct year by year a portion of the originally expended capital, with the object of finally erasing it from the books, because, to do that, it would be necessary to maintain the price of gas enormously. He was interested in the remarks of Mr. Gore with regard to English enterprise abroad, but from what he had seen on the Continent of Europe during three years experience, he found that Continental Companies were infinitely more lavish in their expenditure than any English. They not only spent money lavishly in works, but before the works were constructed, or anything was done in the floating of the Company, a large amount of capital was sunk and wasted. Certainly in Austria it was found that not more than one-third of the capital was represented in actual works, the remainder finding its way into various people's pockets beforehand.

Mr. HUNTER (Salford) said that Mr. Livesey would perhaps inform them how a Company like his own could form a sinking-fund to meet extraordinary expenditure. In that respect probably Corporations might have an advantage over Companies. They might have more freedom in manipulation than a Company. In Salford they got over the difficulty by having two different funds—first a sinking-fund, which was applied to the reduction of the mortgage debt, a certain proportion of the receipts being set aside for that purpose, so that the entire debt would be paid off in about 50 years; then there was another fund for depreciation or replacement, to which they credited each year something like 2 or 3 per cent. Two or three years ago they were unable to put even 1 per cent. on one side, but during the past two or three years they had been enabled to make up for past deficiencies, and put as much as 3 per cent. to it. Last year they put £20,000 to that fund alone. This would soon swell up to a considerable amount, and out of it they could make all the renewals. Though this could be done in a Corporation, he did not know how far a limited Company could do it. The main object of the paper, however, was to show that the capital account should bear some relative proportion to the value of the plant, and the writer had given as a standard 11s. per 1000 feet. There was no question but that this could be done. They could keep their extensions within this margin, and it did seem almost impossible to account for the extraordinary discrepancies which were from time to time brought to light.

Mr. PENNY said he had noticed there was a mistiness in the description given by some gentlemen who had already spoken in reference to repairs and reinstatements, which ought to be cleared up. His experience in examining Companies accounts went to show that in many Companies if a new holder was erected, or new mains were laid down, they contented themselves with charging to capital the cost of the new gasholder or new mains, and then debiting capital with the amount which the old gasholder or old mains produced. That was an explanation, to some extent, of the very large increase in many Companies capitals, and of the great disproportion between the capital of one Company and that of another, as shown by the sum per 1000 cubic feet which the capitals represented. Having regard to this great difference between the capitals of various Companies, he could not help thinking that this had something to do with it, though, no doubt, many practical men present could speak better on that point. As a matter of course, they knew that the old Companies, where they made works of small capacity, and where there had been a rapid growth—where they had to create and recreate—their capital would have a great tendency to swell up. It was a matter of little consequence what the capital was if there was a price for gas that would pay for it; but it was those Companies who had had constant contests, where the maximum price had been kept down, who had been driven to deal with their capitals in a way, perhaps, not the most proper. For when the Board had Shareholders to meet, and dividends to produce, there was a great temptation to deal with reinstatements in the way he had described. There was no doubt that if they had to begin gas-works now, knowing all they did know—taking a square piece of ground, putting down everything of the best form possible—they might make the capital account very small as compared with that of many old Companies. But they ought to have some feeling for those Companies who were born so early, and had had all the difficulties of early times to encounter. Those were the Companies who had been unable to create and maintain any reserve-fund. They were really objects of sympathy compared with those founded in later days, who had the benefit of all previous experience.

Mr. CARR (Halifax) wished to ask whether Mr. Livesey meant the standard which he laid down to refer to the capabilities of the works, or to the quantity of gas they sold. Some small works might be very favourably situated, and, up to a certain time, the capital might be small; but, if they were in a growing district, and had to extend, they might not consider it wise to incur expenditure, with a view to keep within that standard from year to year. They might have to make an addition, which would elevate the standard for the time, until the demand again overtook the supply.

Mr. CHAPMAN (Harrow) said one important point was, whether the preliminary and parliamentary expenses ought to be charged to revenue. As a rule, those expenses were charged to capital. He thought Mr. Livesey's idea was a good one, and his (Mr. Chapman's) Directors had adopted that view. They had a very much larger capital per ton than Mr. Livesey spoke of, as they were a bought concern, like Mr. Stevenson's Company at Peterborough; but they had already written off £452 for preliminary and parliamentary expenses, which amounted to £2000, and intended to write them all off, although they had not yet paid a 10 per cent. dividend.

Mr. IRONS (Gosport) thought Mr. Livesey would add to the obligation he had conferred if he would tell those outside the Act of 1871 what reserve-fund they could form.

Mr. LIVESEY, in reply, said Mr. Carr had referred to Companies getting 10 per cent. That wanted a little correction in this direction. They did not get 10 per cent. after the passing of the Act of 1847 for a great many years—in fact, so long as competition lasted; but when that ceased, full dividends were in most cases secured. It was then the opportunity should have been taken to make those renewals. Mr. Stephenson spoke about the sinking-fund, but the reference to a sinking-fund was intended only to apply to cases, for instance, such as the Chartered Company in building Beckton. It was impossible for the Chartered Company to lay out many hundreds of thousands of pounds, part of which was in place of old works, amounting also to hundreds of thousands, and charge all of them to revenue; but he did think it would be advisable to form a fund which

should in time redeem it. One of the London Companies had, by parliamentary sanction, a leasehold redemption-fund, and there might be seen in their accounts from year to year so much charged on the revenue account to that fund. Where it was a case such as the Chartered Company, they might have obtained a special authority from Parliament for a separate fund; but, in the case of small works, under the Acts of 1847 and 1871, he did not recommend going for an Act of Parliament for such a purpose. Still he thought the ingenuity of accountants might find out some means of meeting this without great difficulty. He did not profess to be a parliamentary lawyer, but he had found this out about Acts of Parliament, that in many particulars they were very imperfect indeed, and certainly not adapted to the circumstances to which it was supposed they were to apply. Therefore, in many cases he should say, if it is right to form such a fund, do it; and who was there to object? There were Companies under these old Acts who were carrying on business in such a way as this. He knew a Company who had hardly called up any capital at all for nine years, and yet that Company had in nine years renewed the works, and converted them from the most dilapidated, wretched state, into a thoroughly perfect condition, and beyond this they had also made great extensions out of revenue, thus reducing their capital, without any objection on the part of anybody. Certainly they had kept up the price of gas rather higher than was desirable, but now they were in a thoroughly sound position, and it would probably be reduced. The right way to deal with ordinary renewals was, that every year should bear its proper proportion. It required some little management to get into that system, but it was thoroughly possible to adopt such a system that the average cost of repairs should be about the same year by year. Again, it was possible to have an undivided balance to carry forward in prosperous years, and that was often done by Companies who might have something over and above the dividend, and possibly over and above the reserve-fund. He could name Companies who had reserve-funds, and then carried forward an undivided balance from year to year. The South Metropolitan, for instance, had their reserve-fund full, and another sum, almost equal, as an undivided balance, in 1872; but, as it happened, the coal famine came next year, and although they had reduced their price, the undivided balance tided them over the famine years very nicely. Where there were no Auditors to look after the accounts, he did not see much use in the Acts. As to Mr. Mead's remarks with regard to gas-works with capitals of from £3000 to £300,000, he had always regarded Mr. Mead as a man who did his work in a thoroughly good way, and on principles of the greatest economy; and, therefore, he thought he must be mistaken when he said that the amount was from 16s. per 1000 feet of gas sold for works from £3000 to £300,000. If Mr. Mead referred to works with a capital of only £3000, he was not going to dispute it, but for works with a capital of £300,000, he did dispute its necessity most emphatically. For works with a capital of £20,000 or less, 11s. per 1000 feet, or £5 per ton, was sufficient. Mr. Mead referred to one particular Company when he said the works exceeded in value the total amount of the capital, and he had already said they were not to be imitated. He thought they were just as far in error in one direction as the others were in the opposite. Those Companies who had reduced their capital below what it ought to be had inflicted a great injustice upon Shareholders and Consumers, and also on other gas people; in fact, they had done badly all round, for the Consumers had had to pay for the extensions which the Shareholders might have provided for out of capital. The Shareholders would have had increased-dividend-paying investments, and the Consumers would have paid a fair price for their gas, and everything would have been right. With regard to Mr. Stevenson, he could quite sympathize with him, but as to paying £30,000 for that which was not worth anything, if any one chose to give a sum of money for that which was worthless, he must look upon that money as lost. It was only the exceptional circumstances in which Gas Companies were placed which enabled them to do such a thing. An ordinary trader could not give £30,000 for a mill which he had to pull down, and expect he was to get interest on that £30,000, as well as on the new building he erected. There might be special circumstances with which he was not acquainted,

over which the Company had no control; but in that case he should say the safe and right course was to endeavour to reduce the capital as much as possible, and to make all extensions out of revenue, which could undoubtedly be done. With regard to the sinking-fund, for any legitimate purpose, such as the redemption of leasehold property, &c., he would consider a certain sum set aside annually for such a purpose as perfectly right, and that, whether provided for in the Act or not, it was not a matter to which objection could properly be taken. Mr. Penny had alluded to a certain mistiness on this question, and he was afraid that was the cause of a great deal of discrepancy in Gas Companies management. What they wanted to learn was the exact way of dividing capital and revenue, and there was a great deal of debateable ground between the two. To take an illustration from railways. One great railway enlarged its stations, and replaced iron rails by steel, and charged all the cost to revenue. Another one enlarged its stations, and replaced iron rails by steel, charging the difference in the value between the new station and the old, and the iron rails and the steel, to capital, though these things did not increase the earning power of the railway to any appreciable extent. He thought the course adopted by the first was the sound principle, whenever it could be done; though he would not say the other was wrong. In reply to Mr. Carr, he did not mean to say there ought to be an exactly defined certain sum for extensions every year, and that they ought not to exceed or go below that; but he maintained that, on the average of years, it ought not to exceed the sum he had stated. As to parliamentary and preliminary expenses, most Acts of Parliament said that expenses of that kind should be charged to capital; but that did not prevent them afterwards being written off. All they had to do was to endeavour to conduct their affairs on such sound principles as they would be compelled to do if it were an ordinary business, and then they would not be afraid either of Acts of Parliament, or Official Auditors, or any other Authorities. No doubt there was a good deal in the paper with which some gentlemen would not agree; but, if so, they were quite as free to hold their own opinion as he was. It was the result of his own experience, and must be taken only for what it was worth.

The PRESIDENT said whatever doubt might have been suggested to the Committee as to the propriety of introducing this paper, had been entirely set aside by the interesting discussion which had arisen. Mr. Livesey had referred to the widespread dissatisfaction which had existed since the Metropolis Gas Act of 1860, as showing that the manner in which Companies had conducted their business had not been satisfactory to Consumers and the Authorities; that the system was not satisfactory, or the results would have been better. He thought there was another way of regarding that question of dissatisfaction which had been expressed with regard to Gas Companies—namely, that since the passing of the Act of 1860, which consolidated and improved the value of the property so much, the London Companies had been paying very full dividends, and then, for the reasons which Mr. Penny had sketched out in his paper, they had been naturally objects of envy, hatred, and uncharitableness. As to the remarks that Mr. Carr had made on the influence of the Act, and the passing of the Act of 1847 having been to secure the payment of maximum dividends, he was glad Mr. Livesey had referred to it, because the influence of that Act was not by any means to secure maximum dividends, or to give anything like security to Companies that they should have maximum dividends. During the whole period between 1847 and 1860 he knew of no instance, and he believed there were very few cases of Companies paying full dividends. During all that time the competition which was thought so desirable to exist between people engaged in any business existed, and the result was high prices and small dividends. The "regulated monopoly" introduced partly by the Act of 1847, and confirmed by the Act of 1860, brought about that condition of things in which Gas Companies rejoiced at the present time. He would only say further that, while it was very desirable to watch the expenditure of capital, it was still more important to see to it that the works were always in full, efficient, and good condition, and money spent in that direction should not be looked at with too close an eye. So long as capital was well spent, it was well to spend it.

PREVENTABLE WASTE.

By Mr. C. HUNT (Birmingham).

It is probable that few manufacturing processes are conducted without a certain amount of waste. When, however, as is said to be the case in the manufacture of iron or of metallurgical coke, this is not avoidable by any known methods, the manufacturer may, with untroubled conscience, pursue his way to further improvements; but when, as with coal gas, such waste, either in the process itself or in the consumption of the manufactured article, is strictly of a preventible nature, with our regrets at its occurrence must be mingled a feeling of something like self-reproach.

It was estimated by the Royal Coal Commission in 1867–68, that the annual consumption of coal within the United Kingdom for gas-making purposes amounted at that time to 6,500,000 tons. Allowing for an increase since then at the moderate rate of 3 per cent. per annum compound, it would appear that the total yearly consumption cannot now be less than 8,500,000 tons. Of this fully one-fourth, or, to be well within the mark, say 2,000,000 tons, representing a cost to carbonize of not less than £1,500,000 annually, may not unfitly be described as preventible waste.

This undesirable condition of things is brought about by very simple means. Pressure within the retort at the moment of evolution, and this same pressure injudiciously exerted at the point of combustion, is directly responsible for by far the largest share; while neglect of the necessary precautions for the efficient maintenance of the distributing apparatus frequently, by the loss which it occasions, operates as a serious check upon the profitable development of gas undertakings.

In submitting a few observations, with the object of pointing out some of the ways by which this enormous annual loss may be diminished, I am aware that I am treading upon ground which has been rendered familiar by the labours of many of our members, and am conscious of the difficulty of finding fresh matter for discussion; yet I trust that some good may result from a periodical recurrence to the subject, and from an endeavour to show that, great as may have been the improvement during the last few years, there is yet room for the exercise of considerably more economy than generally prevails.

In the first place, then, what proportion of this loss may be attributed to the carbonizing process, as ordinarily conducted? We usually gauge the success of this operation by the yield of gas per ton, regard being had to its illuminating power; and there can be no question as to the value of this as a method of comparison. But it is clearly impossible, in this way alone, to determine the results of our operations; for to do this it is necessary to take into account the whole of the products, and compare them, weight for weight, with the coal whence they were derived. When this is done there will be found, in almost every case, a deficiency, varying in amount according to the degree of skill employed, but never less than 7 or 8, and more frequently 11 or 12 per cent.; while instances are numerous in which as much as 24 per cent. of the volatile products is habitually lost. The following examples, which are, to a considerable extent, drawn, so to speak, from the life, are offered in confirmation of this statement.

No. 1 is an example of probably the highest return yet obtained, where coal only is employed, working in the ordinary way:—

EXAMPLE No. 1.

Newcastle Coal carbonised in London.

	lbs.
10,500 cubic feet of 16½ candle gas, sp. gr. ·461, weigh $\frac{10,500 \times 1728 \times (31{\cdot}012 \times {\cdot}461)}{7000 \times 100}$	370·35
10 gallons of tar, at 11·2 lbs. per gallon	112·00
10½ gallons of liquor, at 10·2 lbs. per gallon	107·10
Impurities—	
Sulphuretted hydrogen taken out—say, ¾ per cent. $\frac{78{\cdot}75 \times 1728 \times 36{\cdot}33}{7000 \times 100}$	7·06
Carbonic acid taken out—say, 2½ per cent. $\frac{262{\cdot}5 \times 1728 \times 47{\cdot}26}{7000 \times 100}$	30·62
Ammonia removed after condensation—say, 12 galls., 10 oz. liquor; ammonia, 40 oz. $\frac{12 \times 10 \times 17}{49}$ oz.	2·69
Total volatile products	629·94
Coke—say	1560·00
Total	2189·94
Leaving a deficiency of	50·06
	2240·00

Or $\frac{50{\cdot}06 \times 100}{629{\cdot}94}$ = 7·94 per cent. of the volatile products.

The second is what may be termed a medium example:—

EXAMPLE No. 2.

Inland Coal.

	lbs.
9,400 cubic feet of 17 candle gas, sp. gr. ·468, weigh $\frac{9400 \times 1728 \times (31{\cdot}012 \times {\cdot}468)}{7000 \times 100}$	336·78
11 gallons of tar, at 11·2 lbs. per gallon	123·20
16 gallons of liquor, at 10·2 lbs. per gallon	163·20
Impurities—	
Sulphuretted hydrogen taken out at purifiers—say, 1½ per cent. $\frac{141 \times 1728 \times 36{\cdot}33}{7000 \times 100}$	12·64
Carbonic acid taken out—say, 2½ per cent. $\frac{237{\cdot}5 \times 1728 \times 47{\cdot}26}{7000 \times 100}$	27·70
Ammonia removed in scrubbers—say, 15 gallons of 12 oz. $\frac{15 \times 12 \times 17}{49}$ oz.	3·90
Total volatile products	667·42
Coke—say	1500·00
Total	2167·42
Leaving a deficiency of	72·58
	2240·00

Or $\frac{72{\cdot}58 \times 100}{667{\cdot}42}$ = 10·87 per cent. of the volatile products.

And the third is from the bottom of the class:—

EXAMPLE No. 8.

	lbs.
8,300 cubic feet of 17½ candle gas, sp. gr. ·480, weigh $\frac{8300 \times 1728 \times (31{\cdot}012 \times {\cdot}480)}{7000 \times 100}$	304·99
11 gallons of tar, at 11·2 lbs. per gallon	123·20
13 gallons of liquor, at 10·2 lbs. per gallon	132·60
Impurities—	
Sulphuretted hydrogen taken out at purifiers—say, 1½ per cent. $\frac{124{\cdot}5 \times 1728 \times 86{\cdot}33}{7000 \times 100}$	11·16
Carbonic acid taken out at purifiers—say, 2½ per cent. $\frac{207{\cdot}5 \times 1728 \times 47{\cdot}26}{7000 \times 100}$	24·20
Ammonia which should be removed, but more frequently left in, $\frac{15 \times 12 \times 17}{49}$ oz.	3·90
Total volatile products	600·05
Coke—say	1500·00
Total	2100·05
Leaving a deficiency of	139·95
	2240·00

Or $\frac{139{\cdot}95 \times 100}{600{\cdot}05} = 23{\cdot}32$ per cent. of the volatile products.

In calculations of this kind, it is not easy to be strictly accurate; but I have endeavoured to avoid under-estimating the weight of any single product, so as not to fall into the error of over-estimating the deficiency. Where this is as high as in No. 8, the remedy is doubtless to be found in the employment of an exhauster, which is yet a stranger in very many works, and by the aid of which the loss need never exceed 10 or 11 per cent., while, beyond this, a further improvement is practicable by careful attention to the condition of the retorts; but, however well made clay retorts may be, they are always, to a certain extent, porous; and however well they may be set or built, their soundness is of very brief duration. Consequently, it is not to be wondered at that a large proportion of the gaseous matter, which it is our object to secure, finds its way, not up the ascension-pipes, as we would have it, but through the flues, and up the chimney stack, at the top of which, especially if the stack be a short one, its presence is generally indicated by a body of flame, more or less considerable. If any one be disposed to question the origin of this flame, which has, indeed, been attributed to wasteful firing, let him try the experiment for himself of removing all pressure from the retorts, when the simultaneous disappearance of the flame will afford convincing proof of its identity with the gaseous matter produced in the interior of the retort.

Another circumstance, pointing conclusively to the mischievous tendency of pressure, is the formation of carbon, which, without doubt, may be regarded as its natural consequence. Viewed in this light, it may be accepted as no slight proof of the advance that has recently been made in the direction of obtaining fuller value from the coal—that much less is now heard than formerly of the difficulty experienced in scaling retorts, or of the various remedies which ingenuity has devised for getting rid of this troublesome product. It is abundantly manifest that, in regard to this, Gas Managers have it in their power to lend conspicuous illustration to the truth of the proverb, "that prevention is better than cure."

It may, however, be taken for granted that with the dip-pipe, however carefully it is adjusted, a certain amount of pressure is unavoidable; and, inasmuch as even this minimum pressure is to be deprecated, the ques-

tion which forces itself upon our attention is, Whether or not is the dip-pipe a necessity? It may, without difficulty, be conceded that, if with the highest state of efficiency can be united the greatest possible security and convenience, such a combination is by all means to be promoted and maintained; but when this involves, as in the case before us, the sacrifice of a certain degree of efficiency, we have a perfect right to question its wisdom, and to ask ourselves whether it is worth the cost entailed. Suppose an account were to be regularly rendered to us at the rate of, say, 10d. or 1s. per annum for every ton of coals carbonized, should we not require to write "value received" before passing it for payment? And yet it is very certain that, indirectly, most of us do pay this, and more, year after year, without inquiry or remonstrance, for the use of the dip.

It may, however, be fairly urged that when, by careful attention and periodical adjustment, this inevitable loss is reduced to its smallest dimensions, we do get value for what remains, in the shape of the unquestionable convenience and absolute security which the dip ensures; and the argument would be conclusive if it could at the same time be shown that such conditions are indispensable to successful working, or that they cannot be sufficiently approximated by other means less open to objection on the score of pressure. Many, indeed, there must be who entertain the belief that such is the case, for otherwise it is impossible to account for the almost universal employment of the dip. But of these I would inquire, Have you satisfied yourselves, by personal experience of other systems, that the dip is really indispensable? Unless this question can be answered in the affirmative, it would seem impossible to account for its retention upon any other supposition than that there exists a widespread theoretical assumption of its value; which may be said to savour too much of a blind adherence to custom to entitle it to much respect. And if it be objected that no convenient substitute for the dip has been devised, I need do no more than refer to the example of Cheltenham, where, under successive Managers, the dip has for many years been unknown. The success which has there attended its abandonment seems to point incontestably to the conclusion that, thanks to the introduction of the exhauster, the necessity for its retention has long since passed away.

Intimately associated with this question is the consideration of the effect produced by forcing the gas, as it is generated, through the tar in the hydraulic main. The writer is not in a position to express any positive opinion with regard to this; but it seems highly probable, from the observations of Mr. R. H. Patterson and others, that its contact with tar has the effect of depriving gas of some of its illuminating constituents. At the same time, it is to be observed that the subsequent washing or scrubbing process is an ordeal scarcely less searching in its effect upon the hydrocarbon vapours than that which it would escape by the non-use of the dip; so that, in the absence of proof, it may be safest to omit from the calculation any advantage that might be possible in the direction of an increased illuminating power.

Following next in point of order comes the loss incidental to distribution. Of that which, being due to defective registration, is apparent only, it is unnecessary to say more than that it is remediable almost to the smallest fraction, as the recent experience of the Chartered Company, if it stood alone, would suffice to show, but which experience is abundantly confirmed by that of others in all parts of the country. So large a per centage of unaccounted-for gas as 25, 20, or even 15, may be said to point to an indifference on the subject of correct measurement which, in ordinary commercial transactions, would be regarded as simply intolerable, while in the gas manufacturer it is, to say the least of it, somewhat discreditable. Nor can the imperfections of the meter, such as they are, be pleaded in extenuation of such a fault, it being clearly upon record that these are completely under control, rigid supervision being all that is needed to secure, within practical limits, accurate registration.

While it may, without difficulty, be admitted that the principal sources of actual waste incidental to distribution are leaky gasholders, bad joints, and worn-out services, all of which it is within the power of the Gas Manager to remove, it is without doubt an open question as to how far

such waste is susceptible of diminution, since a certain proportion is always due to accidental breakages of mains, or to other causes over which the Gas Manager possesses only a limited control; but even such proportion must be regarded as only in a lesser degree preventible, when it is remembered how much can be effected by means of improved arrangements. For instance, the damage done to mains by heavy traffic or unequal subsidence may be minimized by laying them deeper under the ground, and by the employment of larger pipes—small and weak ones, such as 2 inches and 3 inches, being very much more liable to injury than such as are made of heavier metal. In like manner wrought-iron service-pipes may be preserved by coating them with asphalte, or rendered more durable by the adoption of a thicker gauge of iron in their construction. Again, almost absolute immunity from loss from this source may be ensured by the employment of lead pipes; while, according to some, wrought-iron tubes that have been subjected to Professor Barff's process are secure against oxidation for almost any length of time. Too much attention likewise cannot be paid to the jointing of services to main-pipes, which, especially when the latter are thin, is a fruitful source of leakage. It has been said, with much show of reason, that there is no better evidence of the general character of the management of a gas undertaking than is afforded by the condition of the distributing plant, as shown by the per centage of unaccounted-for gas. But, however this may be, it is certain that in no other direction can the Gas Manager obtain a more sure and speedy return for the exercise of ordinary care and vigilance. Instances are numerous of a rapid improvement, under such conditions, to an almost unlooked-for extent. In the case of the late Birmingham Company, for example, the per centage of unaccounted-for gas was, in the short space of three years, reduced from 11 or 12 per cent. to about one-half that amount. All this points to the conclusion that, in this matter, as in others of a similar nature, there is no such thing as finality short of an almost total suppression of even the appearance of waste.

In expressing this opinion I am not overlooking the fact that loss may arise from the action of the law of diffusion of gases, but that this can be anything appreciable, the nature of the material of which our mains and services are made precludes us from believing. A more important element of difference—for loss it is not—is to be found in the variable temperature between the works and the consumers meters, every one degree of variation representing a difference in volume of about one-quarter per cent. This difference is no doubt greatest when the works registration is habitually corrected to 60°, because in the mains the gas is invariably cooler than this by several degrees; but it is probably never more than 1 or 1½ per cent.; and by correcting to a temperature more nearly corresponding to that at which the gas passes through the mains and consumers meters, it can, of course, be made to disappear altogether. Having regard to all the circumstances, it seems impossible to doubt that almost perfect correspondence between the registration at the works and at the consumers meters is possible of attainment; and to this end our efforts should be directed. If our mains and services were laid and maintained, as they might be, almost absolutely gas-tight, we should place ourselves above the necessity for restricting day pressures as a means for diminishing leakage —a most important consideration when it is recollected that, in order to meet the requirements of an extended consumption for heating purposes, we must be in a position to maintain a moderately high pressure throughout the greater part of every 24 hours. If this constant service is to be provided with profit to the manufacturer, it will have to be free from the liability to waste.

The subject of gas-burners is one of recognized importance, and the prodigious loss for which they are directly responsible has very properly been a matter of frequent comment; but it is questionable whether the Gas Manager is to be found who considers himself personally accountable for the imperfect combustion of the gas which he supplies; and hence it is not improbable that objection may be taken to my including thi amongst those sources of waste which it is within his power to control. To a certain extent this objection is no doubt a perfectly valid one, although it would not be difficult to show that our influence, if we chose

to exert it, must be very considerable indeed; but it is sufficient for my purpose very briefly to refer to the importance of the question as affecting our interests, present and future.

Within a comparatively brief space of time, our knowledge of the condition by which perfect luminous combustion may be secured has been greatly extended; with the result that the best constructed burners of the present day compare very favourably with their predecessors of say 20 years ago, being made to yield fully 40 per cent. more light with the same consumption of gas. Satisfactory as this may be, it is by no means so pleasing to reflect that this improvement is profitless to the general body of consumers, in consequence of the almost universal retention, through ignorance, of the old and wasteful forms of burners; so that if the waste from this source alone were to be set down at 25 per cent., it would be found to be by no means an exaggerated estimate. In proof of this it may be mentioned that at the exhibition of gas-heating apparatus recently held in Birmingham, there was exhibited a series of burners, nearly all of them typical of such as are in daily use. On being tested it was found that the difference between the best and worst was 20·41 against 6·92 candles; showing a loss by the use of the latter of no less than 65·7 per cent.; while an ordinary Argand, considered to be a very good one of its kind, of which there are many thousands in use for illuminating shop windows and similar purposes, gave only 13·42 candles, being a loss of 34·2 per cent.

In fairness to the gas, no less than from economical reasons, such a manifest abuse ought no longer to continue. Complaints of bad gas are freely made, which, on investigation, are usually found to be chargeable to the burner; but it is as a means of reducing the cost to the consumer that the importance of dealing intelligently with this question is most apparent. It may possibly be regarded as an incontestable proof of the incomparable vitality of coal gas, that, notwithstanding such an amount of waste, it has not only stood its ground, but increased in popular favour; but have we any guarantee for the continuance of such good fortune? Are there not, on the contrary, at the present moment, signs of a disposition to dispute with us the occupation of a portion of our domains? We may, it is true, be very far from believing in the probable supercession of coal gas, speedy or remote; but with such disbelief, the endeavour to increase the distance between it and possible competitors is perfectly consistent. In making gas light cheaper, whether by means of improved manufacture or by the reduction of the illuminating power at the burner, we are acting in accordance with the conviction that our interests as the manufacturers are practically identical with those of our customers, than which no policy can commend itself as more likely in its effect to strengthen and confirm our position as the principal purveyors of the means of artificial illumination throughout the civilized world.

I have thus imperfectly referred to what appear to be three of the principal hindrances—for so they may be termed—to the further successful employment of coal gas; for it need hardly be said that, in proportion to its cheapness, so is its use likely to extend, more especially for heating purposes. In this latter direction the field for its employment would seem to be of almost limitless extent.

Mr. CHANDLER said he could confirm from observation every word in the paper just read. The former part of it referred particularly to that objectionable part of the apparatus connected with gas-works known as the dip-pipe, and he might say there were other works besides those at Cheltenham which had proved to demonstration that prevention, with regard to the deposition of carbon in the retorts, was better than cure. He had in his mind's eye, just now, some works, situated somewhere in Surrey, where patent dip-pipes had been fixed. Previously the make of gas was only a little over 8000 feet per ton of coal carbonized; but, after they were applied, the make was increased considerably—he believed to over 10,000 feet. He attributed this entirely to the adoption of the patent dip-pipe; in other words, the removal of the seal in the hydraulic main. This caused a smile; but to what were they to attribute the extra

make of gas, seeing it was exactly under the same conditions? This brought him to a remark of Mr. Hunt's, wherein he seemed to hint that the fact of doing away with the dip necessitated the use of an exhauster; but he repudiated that, because the dip-pipe was taken out of the tar or liquor in the hydraulic main, there was any necessity for the exhauster. It was only removing an impediment to the gas getting away into the gas-holder, by lifting the dip-pipe from the seal in the hydraulic main. What was done by using an exhauster but releasing the pressure from the retort —the pressure which was given first by the seal in the hydraulic—on to the condensers, the scrubbers, the washers, the purifiers, the holders, and so on? The dip-pipe gave a half-inch pressure if there was a half-inch seal, and if that was removed it created no greater necessity for the adoption of an exhauster than if it was kept in a hydraulic seal. There were many present who had advocated doing away with a seal in the hydraulic main —Mr. Paterson, Mr. Newbigging, and Mr. Livesey. No doubt there were some others who decidedly objected to it; but if they came to consider the matter, it would be found that to remove the impediment to the gas getting away to the holder must be beneficial, if not in increasing the make, in preventing the deposit of carbon on the retorts.

Mr. Hepworth (Carlisle) said this subject was worthy of a broader basis than the bottom of a dip-pipe. On the general question of waste he spoke some time ago, but there was one point to which attention might also profitably be called, but to which Mr. Hunt had not alluded. He felt sure he had not forgotten its existence, but it was such a prevailing element of waste in many works that some special reference should be made to it. He had before him the analysis of the accounts of the Metropolitan Companies, and he noticed that the consumption of coke for fuel varied from 21 to 33 per cent., and averaged 28. Now, 28 per cent., which was the average of the Metropolitan Companies, was a much lower average than prevailed in many places. Speaking generally on the subject of waste, as borne out in the analysis he had before him, he might say there could be no more profitable occupation of leisure time than for some present to go through these figures and compare them with their own working. He was sure they would find abundant room for checking and preventing waste, which was going on in their own establishments.

Mr. Woodall (Leeds), referring to the statement of Mr. Chandler that where a patent dip-pipe was introduced the yield rose from 8000 to 10,000 feet of gas per ton of coal, though no exhauster was used, said a dip did not necessarily involve a greater pressure than half an inch. But the gasholder could hardly be supposed to show a smaller pressure than 2½ inches; so that the weight of the gasholder would be five times that of the dip, as represented in the retort. Now, if one gained 2000 feet per ton by the removal of the half-inch pressure of the dip, clearly by the removal of the weight of the gasholder, one would get a great deal more. This was a plain case, because, if an exhauster were used, the pressure must be equal throughout the apparatus.

Mr. Mead (Sutton) feared Mr. Chandler had attempted to make out too good a case. He also had visited some Surrey gas-works, and in one case found 18 inches of pressure against the retort; and possibly others present might remember works where there was something like that. In works he had to deal with he endeavoured to remove the whole dip and let the gas pass freely through, and the difference was from 300 to 400 feet per ton of coal carbonized.

Mr. Methven (London) said a previous speaker had referred to figures in Mr. Field's analysis of the London Companies accounts as to the quantity of coke used for fuel. But in comparing the per centage in Mr. Field's book, they must take into consideration also the quantity of coke per ton made, which might not come out to the per centage used for fuel. In some cases the Companies only gave credit for making 33 bushels per ton, and in others 36. That ought to be considered where they compared the consumption for fuel.

Mr. Paterson (Cheltenham) said the mention of the exhauster reminded him of a circumstance connected with the yield of gas, or the loss of gas by the deposit of carbon in a retort, which had not been as yet mentioned —the oscillation or drawing through the dip in the hydraulic main;

because with all mechanical exhausters there was a certain amount of oscillation. The gas could not be drawn away perfectly continuously from the retorts, but there was what was called a pulsation. However, in Cheltenham, they had a steam-jet exhauster in action, and there the work of exhaustion was carried on so steadily that there was no oscillation at all. The gauge on the tap was so steady that, unless some means were taken to increase the pressure or otherwise, it would appear that it was stuck. It was said that the removal of the dip did away with the loss of gas from leakage through the pores of the retort, and the destruction and deposition of carbon on the material of it. The removal of the dip, unless something else was removed, would do nothing of the kind; and in the case referred to by Mr. Chandler, another element came into calculation. It was utterly impossible that the removal of the dip of itself, although it was 5 inches, would give a difference between 8000 and 10,000 feet per ton under the same conditions as to coal, temperature, and so on. They ought not to be content with even 10,000 feet, for in their experiments they could get gas to the extent of 10,500, 11,000, and 11,500 feet per ton. It was quite clear, therefore, that the gas was in the coal, and their effort should be to get it out, and, if possible, store it up and—to carry it on further—get paid for it. The way Mr. Hunt had taken up the question and worked it out was likely to result in very great good. He did not like to give results, but since Cheltenham had been referred to, he might say that they had lately carbonized about 100 tons of coal a day. Of course, their mains were by no means puny, but from that 100 tons of coal they had no difficulty at all, day after day, in realising from 10,000 to 10,800 feet of gas per ton. That was a large yield of gas, and, were he not able to give another fact, he should hesitate in asserting it; and, unless they got paid for a fair quantity, he should say that there was something wrong in the estimate; but, seeing that for last year they got paid for 10,300 feet per ton, he had little hesitation in stating that they did in reality get that yield. There was not much difference in coal, provided it was of a fair quality. Then there was the question of leakage, which Mr. Hunt had carefully gone into, and he had given the preference to lead services. He (Mr. Paterson) did not know whether it was the fact or not, but, in his experience in towns where lead services were universally adopted, there the leakage was much less than where iron was used.

Mr. Peebles (Edinburgh) wished to allude to a point which Mr. Reid drew attention to some years ago, which might account for some portion of the gas which was not accounted for—namely, that, while all experiments on the illuminating power of gas were made at a temperature of 60°, the gas was oftentimes sold at a temperature of 80°. Mr. Reid, some time ago, drew the attention of Gas Engineers to this fact, through the medium of the Journal, but he had not seen it noticed since. In hard winters there must be a great deal of gas sold at a temperature of 30°, but the illuminating power of gas was tested in the laboratory at 60°. Those who had continued the tests over three or four months must, in the result, have a discrepancy in the gas as delivered from the station-meter, which very likely might be at a high temperature compared with the meters of consumers, which were often placed in cellars and other places at a low temperature. This might, in some degree, account for the quantity lost.

Mr. Hunt, in reply, said the course the discussion had taken turned almost entirely on the use of the dip. As one gentleman had pointed out, Mr. Chandler had attempted to prove too much in estimating at 2000 feet the gain from the use of the patent dip. It seemed to him almost impossible to gain anything by it, unless an exhauster were also employed, because the pressure of the gasholders and other apparatus must inevitably be thrown on the retorts. The use of the exhauster was simply to relieve the retorts of that pressure. Mr. Hepworth had referred to the fuel account as being exceptional, in some instances. Although the title of his paper was somewhat general, it was not his intention to include in it every sort of waste in and about gas-works, or he should not have overlooked that question. He might say, however, in comparing the returns with those published by the Metropolitan Companies, that he believed, as a rule, those Companies estimated the use of their coke, and took their make to be uniformly 36 bushels per ton. As a fact, many coals pro-

duced a much larger quantity, so that, in some instances, the fuel account was put lower than it should be. Mr. H. Woodall had referred to the dip not necessarily throwing more than half an inch pressure on the retort, and certainly, if the seal were accurately adjusted at half an inch, and if the water were always maintained in the hydraulic main, it would remain so; but it must be recollected that the hydraulic main speedily became filled with tar, which was of a viscid nature, and, consequently, threw much more pressure on the retorts than was apparent. Mr. Paterson had very rightly referred to the question of what could be get out of coal by experimental works. He found by repeated experiments that the coal which produced in practice 9400 feet per ton of 16½-candle gas, could be made to produce, on an experimental scale, fully 11,000 feet of 17-candle gas. That seemed to him to be a difference which ought not to exist, and they ought, as Mr. Paterson had said, to aim at producing, on a working scale, what they were able to do in the laboratory. With reference to Mr. Peebles's observation as to temperature, he must point out that at the works the measurement was at variable temperatures. If the gas were properly condensed, it brought down the temperature nearly to that of the atmosphere at the works. He would remind Mr. Peebles that 30° was two degrees below freezing point, and if they used wet meters, that would necessitate thawing them before the gas could pass through them. It was therefore too low a temperature to take.

Mr. PEEBLES said he only mentioned 30° as an illustration.

A NEW STANDARD FOR DETERMINING THE ILLUMINATING POWER OF GAS.

By Mr. JOHN METHVEN (London).

That the present parliamentary standard for determining the illuminating power of gas is unsatisfactory, will be disputed by few Members of this Association. If we possess a doubt as to the exact length of a yard, the capacity of a quart, or the weight of a hundredweight, it is possible to have it compared with, and corrected, if necessary, by the recognized standard; also, within the last year or two, a standard burner has been duly deposited, so that we can compare the burner supplied with our photometers. But we are not so fortunately placed with regard to our standard candle, and we are still at a loss to know what a standard candle really is, although we are tolerably well acquainted with the expressions six to a pound, and 120 grains per hour. The Legislature has deemed it sufficient, and Gas Companies have not objected to it, that the light given by a certain quantity of gas shall be compared to, and its value determined by, the light given from a certain number of sperm candles possessing the above qualifications.

It has been clearly demonstrated by Mr. Kirkham, in the able paper he read at the Institution of Civil Engineers, and the results of his and Mr. Sugg's extensive and elaborate researches were brought before the notice of this Association, in the interesting lecture given by the latter gentleman at the meeting in 1870—that the candle is a most unreliable standard, and altogether unfit for determining the illuminating power of gases.

It is now nearly ten years since these serious defects in our standard were pointed out, yet new Companies have obtained parliamentary powers, and existing Companies have been permitted to extend their plant, and all have agreed that the commodity in which they trade shall be subject to this incorrect and unfair standard. Has not the time yet arrived for Gas Managers to exert their influence in a direction which will eventually remedy this?

It is the intention of the writer of this paper, before describing what he considers to be a very good substitute for the candle, to point out some of the evils attached to the present standard, and then to direct attention to some of the methods and instruments which have lately been introduced as standards for determining the illuminating power of gas.

It is generally understood that the results of photometrical experiments are influenced by altering the positions of the wicks of the candles used, and it occurred to the writer to make some experiments with different candles, and note the effect produced by the altered position of their wicks on the delicate instrument invented by Mr. Crookes, which he has termed a Radiometer; and, as these experiments appear to possess interest, the writer has determined to introduce them to the notice of the meeting, trusting that they may prove worthy of the time their explanation will occupy.

The first set of experiments were made as follows:—The candle under examination, after being lit, was hung in a delicate balance; the radiometer was then fixed on a stand, so that the centre of its globe would be in the same horizontal line as the flame of the candle, and fixed by means of fine plumb lines exactly 6 inches away from the centre of the flame, the whole being protected from draughts and reflected light by suitable screens. The candle being balanced, the minute clock was started, and for ten minutes observations were made of the number of revolutions of the radiometer. At the end of the ten minutes the candle was extinguished and weighed, the rate of its consumption of sperm and the number of revolutions of the radiometer being noted. Each candle was tried four times, the position of the wick being altered

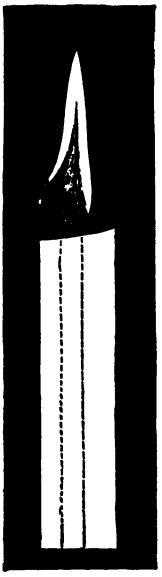


Illustration of a Sperm Candle, showing position of Centre of Flame compared with Centre of Candle.

each time. The results obtained from six different candles are marked on diagram 1, the vertical lines representing the different consumptions of sperm in grains per hour, and the horizontal the tenths of a revolution of the radiometer. The black marks are formed to indicate the position of the wicks. It will be observed that, if there had been a regular increase of illuminating power given by the candles with an increased consumption of sperm, the marks would appear all on one horizontal line. This, however, is not the case, neither does it indicate that a candle gives more light, with its wick at right angles to the radiometer, than it does in any other position; but it proves what an irregularity there is in the amount of light emitted by this uncertain standard.

Feeling tolerably well satisfied with the results of these experiments, the writer undertook a second series with the centre of the *candle* fixed exactly 6 inches away from the radiometer. Three times each candle was tried, with the wick in a different position each time. Diagram 2 shows the results obtained from an examination of seven different candles. Each candle will be distinguished with its wick in the different positions, and by its colour. It will be observed, in all cases, that when the wicks were turned away from the radiometer, the number of revolutions was low, compared to those in which the wicks were turned towards the instrument, and that always when the wicks were at right angles the number of revolutions was about midway between the two. This peculiarity was not observed in the first series of the experiments, because the centres of the *flames* of the candles were in that case the fixed distance from the radiometer; but in the second series the centres of the *candles* (disregarding their flames) were the fixed point, and it is interesting to observe the great effect produced on the radiometer with the wick in one case bending towards it, and in the other bending away from it. One instance marked on diagram 2—wick turned from the instrument—revolutions per grain consumed, 5·66; wick turned towards it, revolutions 7·57; showing an increase of 33 per cent. Taking all the candles marked on diagram 2, the average increase in revolutions per grain consumed amounts to 22½ per cent. The altered position of the flame of the candle each time the position of its wick was moved was hereby clearly indicated by the sensitive character of the instrument. And, it was found by careful measurement to be about three-eighths of an inch—*i.e.*, the centre of the flame (the candle being turned on a fixed centre) would describe a circle three-eighths of an inch diameter.

Several experiments were tried in the usual manner on the ordinary photometer, resulting in a difference in the quality of the same gas of over one candle, by using the wicks in one case turned away from the disc, and in another turned towards it; and in all cases when both wicks were at right angles to the bar of the photometer, the result was a mean of the two previous tests. A reference to diagram 2 will show the similarity between these tests and those recorded by the action of candles on the radiometer—sufficient evidence to remove all doubt as to this instrument being reliable for the purpose it was used. Heat-rays from the flames of the candles undoubtedly had their respective influences in operation, in addition to the luminous rays; yet we are able to form a fair comparison, as the whole of the experiments were made in the same way, and similar results shown.

The above results of experiments, although they are as drops compared to the ocean of facts clearly proved by Messrs. Kirkham and Sugg, tend to show, firstly, that candles do not give an uniform light, even when exactly the same weight of sperm is consumed; secondly, that there is no more light given by a candle with its wick in one position than in another, provided that the centre of the flame be the fixed point; and, thirdly,

that unless (in using an ordinary photometer) the gas to be tested is compared with the centre of the flame of the candle, the resulting observations will be misleading. From this we may conclude that as there appears to be no uniform amount of light given by candles, even when of the same make and apparently exactly alike, it is an unsatisfactory standard, and that if we are compelled to continue its use, it is absolutely necessary that the *centres* of the *flames* should be in the proper position on the photometer bar. Under these conditions it is possible to improve the candle as a standard, and diminish the chance of error in its use; but as photometers are generally constructed (unless of the class recently improved by Mr. Sugg), so that the candle-holder is fixed a certain distance from the burner, it is left in the option of the operator to place his candles with the wicks in any position he chooses. The results of this latitude of discretion on the part of the operator might prove very serious to a Company who are compelled to supply a certain quality of gas under penalties. Engineers of these Companies are, therefore, compelled to make gas of such quality as to allow for the variations of the present standard; and as it is quite possible for Examiners to make the same gas vary to the extent of one candle—half a candle in favour of the Company, and half a candle against the Company—by merely altering the position of the wicks of the candles, it is necessary to make the gas, at any rate, of half a candle higher quality than there would be necessity for if the centres of the flames were the fixed point; or, in other words, if the wicks of the candles were always turned at right angles to the photometer bar.

This matter assumes a serious aspect when we look at the cost in London alone of this extra half candle. Assuming that to enrich 16-candle gas to 16½ candles costs one halfpenny per 1000 feet, and at this figure it is not over-estimated, the total quantity of gas made in London in 1876 having been 15,629,484,000 feet, it amounts to no less a sum than £32,561. That this expenditure might be considerably reduced, if not altogether saved, there is little doubt, if an uniform and unvarying standard was adopted.

The writer would suggest that so long as the candle continues to be the standard, the Referees should be required to direct the Gas Examiners to place the candles with their wicks pointing across, or at right angles to the photometer bar. But we are not all subject to have our gas tested by experienced operators, and any edict issued by the Referees would only affect a small proportion of gas-makers. The writer can well understand the indignation of a Gas Manager, when, just to wind up his laborious daily duties, he estimates the quality of the gas in his holder, by an experiment with his photometer, to be equal to 15 candles, he having unintentionally used the candles with their wicks leaning away from the disc, and rests satisfied with what he conscientiously believes to be the true value of his gas. When, however, his Examiner, equally anxious to act conscientiously, arrives at a very different result, the wicks of the candles he uses happening to be turned in the opposite direction, and he believing also in the satisfactory test he has made, publishes to the consumers the information that the Gas Manager has been making and delivering gas of an inferior quality. Such then is the standard that both skilled and unskilled Examiners have to operate with at the present time.

The remedy for this evil undoubtedly is to substitute an unvarying standard, and one which can be depended upon. The question still remains, How is this to be accomplished? Several suggestions have lately been made for improving the standard, among which, that of Mr. Vernon Harcourt is one of the latest. But, to the writer, the preparation of pentane gas appears to require great skill and care; great difficulty also will be found in keeping the water-line of the meter accurately adjusted, and the hight of the flame exactly defined, even with the aid of a platinum wire. These difficulties render this test unfit for ordinary practical purposes.

Next in the order of consideration (and, from its extreme simplicity, it might well have been placed first in the list) is the ingenious discovery of the radiometer by Mr. Crookes, which demonstrates the fact that light is capable of exerting mechanical power. This appears to be everything that can be desired, as far as determining the power exerted by different flames; but the delicacy of the instrument necessary to record the

revolutions, as at present constructed, will probably prevent its ultimate adoption as a standard.

The illuminating power meter designed by Mr. Sugg is a very serviceable instrument, but it is considered by some to possess the same disadvantage as the pentane standard in the difficulty of regulating the height of the flame, with this important advantage, however, that the errors would be small compared with Mr. Harcourt's shorter flame in his standard.

It has also been suggested to substitute an oil lamp (as is adopted by the French for their standard) for candles; but then we have the difficulty of procuring oil of a constant quality, its liability to be affected by change of temperature, the even texture of the wick and consequent form of the flame, and the effect of atmospheric influence in its combustion.

Lowe's jet photometer, as improved by Messrs. Kirkham and Sugg, is a very useful instrument for the purpose, and recommends itself as being much more reliable than the candle.

For some time past the writer has been considering the subject of this paper, and his investigations have convinced him that it is possible to form an unvarying standard for determining the illuminating power of gas burning at one end of a photometer, by comparing it with a portion of the most luminous part of a flame of the same gas, or of gas of any other quality, consumed by a similar burner, at the other end of the photometer, in the position occupied at present by the candle. In other words, he has discovered that portions of the flames of gases of varying qualities, ranging in illuminating power between 15 and 35 candles, consumed so as to effect perfect combustion by similar burners, are equal in illuminating power.

The above engraving represents a 60-inch Letheby photometer, which illustrates the manner in which it is proposed to use the new standard. The burners used in making the various experiments, and which are considered most suitable for the purpose, are the same that the Referees have adopted as the standard burner. They are capable of consuming gas of any quality up to 40 candles with perfect combustion.

In front of the burner, between it and the photometer disc, is fixed a brass screen, with provision similar to that of an ordinary candle holder, for fixing it at the end of the photometer bar. The tube on which the burner is fixed is provided with a T-piece and union joint, to which can be attached a flexible tube from the ordinary service to the photometer, supplied with an ordinary micrometer cock and governor, to facilitate the adjustment of the height of the flame. The end of the tube is fixed on a stand, so that the whole may be lifted off the end of the bar at any time. A hole about one inch in height and one-quarter of an inch in width is cut in the screen, of the form and in the position shown on drawing, which will be found sufficient to allow an amount of light to pass through it equal in illuminating power to that given by two standard sperm candles. Screens must be provided to prevent any other reflected light acting upon the photometer disc.

After lighting the gas at both burners, and adjusting the rate of consumption of the gas to be tested, the operator will be able, by one observation, to determine its illuminating power. The size of the aperture on the brass screen might, if desired, be reduced so as to allow sufficient light to pass through, equal in power to 1 candle only, and this would appear preferable, as the scales of photometers are marked for 1 candle, but then the advantage of the more equally illuminated disc would be lost.

The manner in which the experiments were conducted, which enabled the writer to arrive at the above conclusions, were as follows:—He used an ordinary 100-inch photometer, fitted with necessary screens; a Referees standard burner at each end, connected to their respective meters and governors; and two small gasholders, one filled with common gas, equal to 15-candle power, the other with cannel gas, equal to 35-candle power. The burner on the right was supplied with common gas only; that on the left with a service from both common and cannel. The meter of the right-hand burner was adjusted to a steady consumption of common gas of 5 feet per hour. In the first place it was necessary to determine the most suitable form of aperture to be used in the screen. This was arrived at by a series of experiments representing an analysis of each flame. The left-hand burner was fitted with a tin screen, with a large hole in it, about

8½ inches high and 1½ inches wide, and a smaller screen with an aperture about 1½ inches wide, and 3-10ths of an inch high, made so as to be easily moved in a vertical direction, and sufficiently deep to cover the large hole in the first screen. This enabled the writer to ascertain the amount of light given from the same portion of the flame of each gas. The plate on which this screen moved was marked 3 inches from the top of the burner, and carefully divided into ten spaces, each space corresponding in depth to the aperture in the moveable screen. Five observations were made, and the average recorded with the screen in each of the positions, common and cannel gas being alternately burnt in the burner behind the screen.

The tables appended to the paper show the results.

Referring to the average of the four sets of experiments in Table I., it will be seen that the position of the greatest amount of illuminating power of the flame of cannel gas is lower down the screen, or flame, than that from common gas—*i.e.*, No. 6 of common appears to be equal to No. 5 of cannel. Combustion appears to take place nearer the burner in the case of the latter than in the former. Taking three sections of each flame, 5, 6, and 7 of common, and 4, 5, and 6 of cannel, there is a very slight difference in the average of each. It, therefore, occurred to the writer that, if the aperture embraced portions of three of these horizontal spaces, it would be the best form of screen to adopt, and so it has proved itself to be. The results shown on Table I. were arrived at by using an aperture which embraced the whole width of the flame, and the variations in the results indicated are produced by two causes—first, the alterations of the width of the flame; and, secondly, the bright portion of flame which is easily observed at the edge of the flame from an ordinary Argand burner. The adoption of the vertical aperture excludes these causes of variation, and the results arrived at are quite satisfactory. It is possible to fix the screen with the vertical aperture, so that the same amount of illuminating power of flame will pass through it from both gases. Out of the whole number of long experiments the writer made—three of which are recorded on Table II.—their averages did not vary more than 2-10ths of a candle, between the power of the light through the screen with common and cannel gas, and in many cases the averages of ten observations of the one were equal to that of the other—clearly proving that a portion of the flame of 15-candle gas was equal in illuminating power to a corresponding portion of the flame of 35-candle gas.

In the last-mentioned experiments, the range of 20 candles between the quality of the two gases is so great that even if a slight variation was found between the two, it would be proportionately diminished if the quality of the two gases were nearer alike; but as it was the wish of the writer to thoroughly convince himself of the adaptability of the standard he suggests, before bringing it under the notice of the Association, he was particularly anxious to submit it to the most severe trials, and as the results which have been arrived at, and referred to above, appear so satisfactory, he has the greatest confidence in introducing the subject to the notice of the meeting as an unvarying standard for determining the illuminating power of gas. It possesses this advantage—that the quality of the gas to be tested may be arrived at by one single observation, thereby saving time. It is not dependent upon the height of the flame being accurately adjusted. The colour of the two flames being alike, the illumination of both sides of the disc will be nearer alike. It is not sensibly affected by atmospheric influences. It can be used by skilled and unskilled operators without the chance of error, or of the photometer being converted into a misleading instrument, which now it unfortunately is often made to appear.

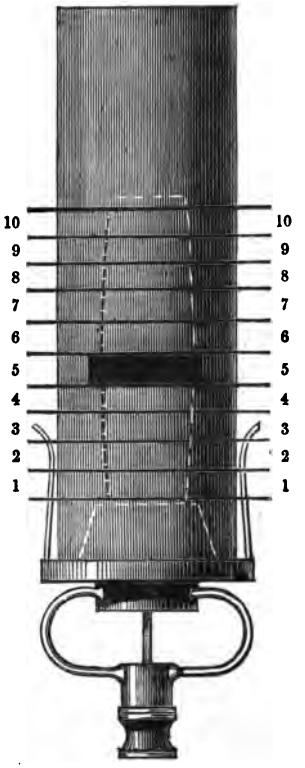
The writer's acknowledgments are due to Mr. Sugg for his kindness in constructing an apparatus, and fitting the same to one of his most recently improved photometers; also for his trouble in exhibiting his illuminating power meter, and improved jet photometer, all of which are in operation for the inspection of members. Also to Mr. Kirkham for the loan of his large diagrams, which are hung on the walls for the purpose of reminding every one concerned as to what has been done in years gone by in the matter of exposing the ridiculous standard we are at present using. And, lastly, the writer's thanks are due to the meeting for the kind attention he has received. In conclusion, he trusts he has succeeded in

convincing the members that the test suggested is genuine; but if he has failed in this, he will be quite satisfied if any remarks he has made concerning the present unsatisfactory standard have the effect of assisting in the establishment of some other standard worthy of its name. If, however, he fails in this, he will truly and feelingly say, "*Le jeu ne vaut pas la chandelle.*"

TABLE I.

Experiments to determine the Form of Aperture to be adopted.

Common Gas = 15 Candles.		Cannel Gas = 35 Candles.	
10·50		12·00	
11·15		10·53	
11·15		11·38	
12·00	8	12·00	7
4)44·80		4)45·91	
11·20		11·48	
6·50		6·80	
4·85		5·94	
6·12		5·95	
6·10	7	6·50	6
4)23·57		4)25·19	
5·89		6·29	
4·65		4·55	
4·11		4·09	
4·25		4·25	
4·65	6	4·50	5
4)17·66		4)17·39	
4·41		4·34	
4·10		3·55	
3·58		3·32	
3·82		3·32	
4·05	5	3·55	4
4)15·55		4)13·74	
3·88		3·43	
4·70		6·30	
5·84		5·67	
4·56		5·78	
5·14	4	6·45	3
4)19·14		4)24·20	
4·93		6·05	
3·88	5	3·43	4
4·41	6	4·34	5
5·89	7	6·29	6
14·18		14·06	
4·73		4·69	



HORIZONTAL APERTURE IN SCREEN EMBRACING WHOLE WIDTH OF THE FLAME.

Four series of experiments, each being the average of five observations.

TABLE II.

Result of Experiments with Vertical Aperture in Screen.

Cannel.	Common.	Cannel.	Common.	Cannel.	Common.
6·70	7·25	7·10	6·85	—	—
6·80	6·85	6·85	7·10	—	—
7·00	6·80	6·90	6·95	—	—
7·20	6·85	7·00	7·15	—	—
6·80	7·05	6·90	7·35	8·80	9·00
7·10	7·30	7·20	7·50	9·10	8·55
6·70	6·90	7·20	7·40	9·00	8·80
7·00	6·85	7·15	6·95	8·85	8·70
7·15	7·10	6·90	7·10	8·90	8·55
7·25	7·00	7·10	7·15	8·90	8·70
69·70	69·95	70·80	71·50	53·55	52·80
Aver. 6·97	6·99	Aver. 7·08	7·15	Aver. 8·92	8·72

Flame of each gas in screen burner adjusted to a height of 3 inches.
Gas at opposite end of photometer burning 5 feet per hour in all cases.

The PRESIDENT said as Mr. Vernon Harcourt was present he would ask him to describe his apparatus.

Mr. VERNON HARCOURT said: Not having expected to be asked to describe the standard I propose, I have not had an opportunity of placing it before the eyes of Gas Managers. Naturally, I do not myself think that the apparatus I have proposed is complicated to the degree to which Mr. Methven seems to think it, and I will endeavour, if I can, without having the apparatus before me, to describe it sufficiently for those present to understand. I prepare, in the first instance, a gas of constant composition. It is very readily made, for it is a mixture of air, whose composition is constant, with the vapour of a hydrocarbon which can be readily obtained from a few rectifications of the petroleum now largely sold for the production of air gas. It is of constant chemical composition, constant specific gravity, and nearly constant boiling point. The preparation consists in bringing first into an experimental gasholder a measure of air. The gasholder is furnished with a scale by which the quantity of air passed in can be read off. The one I have been employing is of such a size that I find 3 cubic feet to be a convenient quantity. In the crown of the gasholder there is a tap through which I pour in, from a measure, a quantity of pentane, which is the hydrocarbon I use. This substance is really more easily obtained definitely than either alcohol or other more familiar substances. That is simply a question of experiment. I have distilled the substance on a tolerably large scale several times, and determined the specific gravity for the products, and although there is no way of proving such a fact—one can merely state it—there is no difficulty whatever in obtaining by the gallon this liquid of uniform composition. It is extremely volatile, so much so that when a small measure of it is brought into 3 cubic feet of air, it volatilizes immediately, and forms a gas which is permanent under the greatest atmospheric pressure, and at a temperature below the freezing point of water. Thus I make a gas which consists of nearly 1 cubic foot of hydrocarbon vapour and 3 feet of air. The two conditions necessary for a photometric standard are—first, the production of a combustible, of constant composition, to give the light; next, conditions of burning which are definable and easily reproducible. The conditions of burning I propose are that the gas shall be burnt at the end of a piece of brass tubing, 1 inch in diameter, and 4 inches in length, closed by a plug half an inch in thickness, and perforated by a quarter-inch hole. I take this with a view to have simple measurements, all on a large scale, so that there is no part of the burner which, with moderate trouble, cannot be reproduced in one case exactly as it stands in

another. That all quantities to be adjusted shall be sufficiently large that the errors occurring in making shall be immaterial, appears to me to be an essential condition of success. With this burner I burn the gas in the proportions I have described. The proportion between the air and gas so described is such that, when burnt at the rate of half a cubic foot per hour, the light given shall be equal to the light of an average standard candle. I check the quality of the gas I prepare by measuring the height of the gas. I fix a piece of platinum wire immediately above the orifice of the burner at a height of $2\frac{7}{16}$ of an inch. It is perfectly easy to ascertain whether the flame that is being produced is the right flame or not, and if it is, when the gas is burnt at the rate of half a cubic foot per hour, the top of the flame will precisely touch the wire. If the gas is too poor for the flame to touch the wire, it will have to burn at a greater rate; if too rich, at a lower rate. I have made a number of observations in order to choose this flame, so that it shall correspond with the average flame of a candle. I entirely agree with the remarks Mr. Methven has made as to the inaccuracy of the present standard. I have worked with it a great deal, making candle testings for a great many years, and nothing can be more unsatisfactory than the endeavour to obtain accurate results in a quantitative operation in which the standard that is used varies so extremely as, I believe, with all possible care, the standard sperm candle does vary. Mr. Methven has dealt with a particular source of error—a grave source, I have no doubt, and one which it is fair to mention was pointed out in the JOURNAL OF GAS LIGHTING, some years ago, by Mr. Young, that, when the candle bends over, as it does always, it throws the flame a little out of axis. This, I think, fairly might be remedied, in the case of two candles, by arranging the wicks so that they may look opposite ways as the candles burn down. If they are rightly placed, the movements of the two will correspond to one another, so that the mean position will be about alike. There are other more grave errors to which candles are liable. One is the difference in amount of light, given according as the cup of the candle is filled with melted grease, or is drained dry. This difference is produced by so slight a cause as opening a door or a very slight draught, and it does not pass off at once, but continues for ten minutes. The candle may be burning brightly or low, and, as the cup is full or empty, you find the difference of light, which is by no means fully compensated for by the customary allowance for the difference in the amount of sperm burnt. Another difference, still more difficult to deal with, is the accumulation of ash at the top of the wick when the candle has been burning in still air for some time. However well the wick is made, there is a considerable accumulation of ash at the end of the wick, which greatly reduces the light of the candle. A slight shock to the candle, or a slight draught, may cause this bunch of ash to fall off, with a sudden improvement in the light, so that I have found, in making experiments with the apparatus, that the removal of this, after making a set of observations, would cause a variation, in the apparent illuminating power of the gas tested, of two candles. The matter has really been made out to the satisfaction of all who have had to do with it, and the question which has to be solved, if possible, is to provide some substitute for the candle. It seems to me that a candle has this advantage; it is a familiar and tolerably intelligible one. It gives some kind of rough notion of what is meant by the illuminating power of a lamp, if we say it is equal to that of 16 or 10 candles. But I do not think that will be at all sacrificed by the substitution of another true unit of light in the operation of photometry. Just as we still retain such terms as a foot or a grain as measures of length or weight, although we no longer use a foot as an actual measure, or a grain as an actual weight, so I think 16 candles may fairly remain as a description of a particular kind of gas. I am afraid I am scarcely able to offer any criticisms as to what Mr. Methven has brought before you, seeing the apparatus for the first time. I remember, when Mr. Sugg gave an account of his illuminating power meter before the Institution of Civil Engineers, he made then these statements:—That however the quality of gas that was being burnt varied, if the flame were kept about the same, the actual light given was the same; that gas-flames burnt with a particular burner varied not in brightness but in size; and

that the actual amount of light given per unit of light is the same, whatever the quality of gas burnt. I understand Mr. Methven chooses a hole of a particular form and at a particular distance from the burner to exclude all but the least portion of this tolerably uniform light, and that this portion of light passing through the screen may correspond to the light of two candles. As I have said, it is difficult, if not impossible, without having experimented with such an apparatus, to form for oneself any judgment as to the degree of accuracy obtainable with it, and I would only ask that Mr. Methven, having been in the same case as I have with regard to his apparatus, and not having had an opportunity of making any comparison, will be equally willing as I am to reserve his judgment in the matter.

Mr. GEORGE LIVESEY said that, having used Mr. Harcourt's method for a considerable time, he could corroborate what had been said, and had found no difficulty whatever in the management of it. The question of getting the proper height of the flame was not a difficult one in any sense whatever. There was just the simple flame, and he believed it was a means of testing infinitely superior to the candle. He was not going to say that Mr. Methven's might not be better, and if, by other experiments, it was proved that that simple apparatus, with a slit in the intercepting plate, could be depended upon to give a uniform quantity of light under all circumstances, it seemed an exceedingly simple arrangement, and one which could be applied anywhere and everywhere. Whether they could get the public to believe that they were receiving a proper quality of gas, when the standard by which it was tested was the gas which was being tested, he was not quite so certain. He feared the public would be apt to say that it was so managed as to "do" them in some way or other.

Mr. WARNER (South Shields) said there could not be two opinions as to the interesting nature of this discussion, and the paper had come in very opportunely with Mr. Harcourt's description of his apparatus. One question he wished to ask was, In what manner did this process of Mr. Methven's differ from the principles set up by Mr. Fiddes some years ago? He remembered visiting his works at Bristol some time afterwards, when he gave him an interesting account of the work he had been doing, and he wished that gentleman were present, as he might throw a little light on the subject.

Mr. HARTLEY (London) said he hardly dared venture to say a word in favour of candles, which seemed to have gone completely out of favour of late, although there were still some users who considered a candle to be an exceedingly good standard. There was one difficulty in the adoption of a new standard—that the Acts of Parliament would have to be modified before any other standard could take possession of the field. With Mr. Harcourt's test he was perfectly familiar, and he must acknowledge there was no difficulty in using it. He had prepared the gas, and could assert that it could be used with facility. In the paper just read he found reproduced a scheme with which he was familiar some years ago, and with which he worked for a considerable time—that of Mr. Fiddes. Unfortunately, he could not obtain with that arrangement the same result which Mr. Methven said he had obtained. He found that unless he maintained the flame at a very constant height, and if, moreover, he had variations in the quantity of gas, there were variations in the indication given by the instrument, and, therefore, that he could have no standard, and could put no dependence, in fact, in the indications given by the photometer. Mr. Methven had startled him considerably by stating that a range from something like 16 up to 35 candle gas enabled him to get the same illuminating power through the apertures he had in his opaque chimneys. He was not prepared for that, because he found, when working with Mr. Fiddes's arrangement, great divergences; and, unless the aperture was very carefully arranged, and, not only so, but the height of the flame very carefully maintained, he ran a great risk of having the luminous point raised into different positions, and, therefore, failed to get the same indications on the photometer. With regard to candles, all he could say was that the defects arose from the non-observance of the due conditions which should belong to the use of candles. If, as indicated by Mr. Young, years ago, the candles were placed at right angles, so as always to preserve

their centres in due relationship to the disc, the difference would not be so extreme as Mr. Methven indicated; but if the candles were allowed to burn anyhow, one might expect to find a considerable divergence in the results. He mentioned years ago some points he thought should be regarded in the use of a candle, and certainly he had never been able to find such extreme divergences as appeared to have been noticed by others, though those differences and divergences did sometimes arise, he had no doubt. Certainly candles did vary considerably, and in asking operators to use candles, he asked that they should be burnt properly, with the wicks properly centred, and if they were not, that the candles should be rejected. The radiometer had been referred to, but that Mr. Methven did not prefer to use as a photometer, although he had obtained manifestations which were very interesting. He (Mr. Hartley) did not know whether that was ever likely to be found useful, for he had never settled how far the influence of heat operated in contradistinction to light. He should feel great pleasure some day in seeing a better standard, and if it were such a one as ought to be adopted, he had very little doubt that alterations in Acts of Parliament might be made to suit this or Mr. Harcourt's test, which he had had the pleasure of working with for some time, but he thought there would be considerable difficulty in persuading the Legislature and the public that such a change was desirable or necessary.

Mr. Hislop (Paisley) thought that so long as candles were used, there should be some definite understanding as to the position in which the wicks were placed. He had given his views on this subject in the Journal of Gas Lighting—namely, that the back of one wick should be turned to the photometer-bar, and the broad side of the other, so that the exact mean of the flames at the centre should be secured. He held that if the broad side of the two candles were placed towards the bar, the true light of the candles was not obtained, as there would be more than the due proportion of light sent in two directions. One reason why he believed a considerable difference might arise in the results obtained by different experimenters was the use of funnels on the top of the photometer-boxes. Many boxes were used, closed in front, with a curtain to hang over to exclude the daylight, and it was the practice to provide them with funnels at the top. Many years ago he had one supplied to him, and could not, by any means, get the candles to burn steadily, neither in regard to the oscillation of the flames, nor the quantity of sperm consumed, until he took off the funnels. Indeed, he had to all but close the opening in the crown of the box with an iron plate, leaving only about an inch or an inch and a half uncovered, and then he obtained a perfect steadiness of flame, never exceeding a variation of half a grain in the consumption of sperm. In common with his friend Mr. Hartley, he had given a very fair trial to Mr. Fiddes's method of illuminating the bar through a $\frac{3}{8}$-inch hole in a copper tube, substituted for the ordinary glass chimney over an Argand burner. If he remembered rightly, it was placed exactly $1\frac{1}{2}$ inches from the top of the burner, and was supposed to give a light of one candle. He gave it a fair trial, but was obliged to abandon it. They were all at one, however, as to the desirability of having one standard which they could all adopt, and obtain satisfactory results from on all occasions. He hoped the new method would result in a complete success.

Mr. Ball said he had just been working for about three weeks with a photometer, and he had been working not only with candles, but with one or two other things as well. They had just been making a long series of tests, and when they got some distance through them, having tested about 25 or 30 samples with a great many variations of results, it occurred to him to change the disc in the reflector on the photometer-bar (which was a 60-inch Letheby), with the startling result of an addition of two candles to the illuminating power. This was a matter which could scarcely be overlooked when it affected some parties to a serious extent, and it necessitated commencing the experiments all over again. In addition to this defect, he found, as Mr. Harcourt had said, that if any interruption occurred during the observation, such as the opening of the door into the room, it materially affected the illuminating power of the candles for perhaps two or three minutes, so much so as to necessitate a fresh observation

altogether, and particularly if it should happen to occur towards the end of the test, when the consumption of sperm could not possibly make up for the difference in the illuminating power. It would be sometimes equal to one and a half or two candles. He should be very glad if Mr. Methven's system should prove a success, because it would materially reduce their labours once a year, at all events, if they could take one test, instead of having to take 10, 20, or 30.

Mr. PEEBLES (Edinburgh) was glad Mr. Methven had taken up the radiometer, which he thought had not received the attention it should have had from gas analysts. If he mistook not, Mr. Goodwin, of Philadelphia, made some experiments in connection with the radiometer, and gave the results at one of the meetings of the American Association. He saw Major Dresser, the Editor of the *American Gaslight Journal*, present, and perhaps he could state what those results were. He might say that, as the Association talked about visiting Scotland, they might possibly, in a year or two, hold a meeting in America, and, if they did so, he was sure there would be no one more willing or anxious to extend the hospitality of the New World to them than Major Dresser. At any rate, he could speak in the warmest terms of the kindness with which he and one or two friends had been received in America.

Major DRESSER said he had had a long connection with the gas business, but his duties were more to make public what other men did than to give any facts with reference to what had been done by himself. After thanking Mr. Peebles for the kind manner in which he had referred to the small amount of attention which had been paid to them, he said he would second most heartily the suggestion thrown out by that gentleman, and if the Association would go to America, he was sure they would have such a reception as only the gas makers of England were entitled to from the gas makers of America. With reference to the experiments of Mr. Goodwin, they were given at a meeting of the American Association at Cincinnati. He simply found that, taking gas of a known illuminating power as previously determined, the motion of the radiometer did vary with the different illuminating powers of the gas. He did not think the matter had been fully investigated, and merely indicated that as a line which might be pursued with interest by those who desired that most desirable of all things, a fixed standard for illuminating power. They were blest in America with very little in the way of examination, and as long as they could say that the candles they used were candles imported from England, that they were standard candles and must be right, the ordinary alderman succumbed. He should be very glad if he could go back and say to his fellow-countrymen, who watched their brethren in England more closely than they had any idea of, that they had found something which was an absolute standard.

Mr. METHVEN, at the close of the discussion, said that the only question he had really to answer was that of Mr. Warner, who asked whether this method was similar in idea to that of Mr. Fiddes. Until he was informed of the nature of this experiment by Mr. Hislop, he was not in a position to say; but from what he gathered, Mr. Fiddes's idea was to take a portion of the flame, to cut a hole in the brass screen which surrounded the flame, to allow that portion of the flame to act on the photometer disc, without any regard to the steadiness of consumption of the flame, or anything else. If that were so, there was no difficulty in seeing why it did not answer. The screen he adopted was immediately in front of the burner, burning with a steady flame inside a chimney. He could only refer to Mr. Sugg's illuminating power meter, which, as Mr. Harcourt said, resembled his in principle. It purported to record the illuminating powers of different gases varying in quality, simply by regulating the height of the flame burning through the same burner. Although he did not take his idea exactly from the illuminating power meter, it was the same principle. The facts he had stated were correct, and he should be pleased indeed if any one sufficiently interested in the matter would come to his works, where he would explain the process more fully. He need only add that he was not personally interested in the matter at all, and brought it forward thinking that it would be interesting, knowing that a new standard was much required.

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THE PRODUCTS OF COMBUSTION.

A Lecture delivered at the Evening Sitting

By Mr. THOMAS WILLS, F.C.S., F.I.C.

Mr. President and Gentlemen,—I occupy the position of your Lecturer to-night with some amount of diffidence, which arises from two causes. First, I know that at these annual gatherings you look for some light to be thrown, and some information to be given, by your Lecturers, upon some of the processes with which, in the exercise of your profession, you are practically so familiar. Then again I remember that those gentlemen who have preceded me in this position have been able to rely upon an amount of experience in matters connected with the gas industry, to which I can in no way lay claim. I should have been glad, had I been in a position, to bring before you the results of some new investigation, which might have advanced your knowledge in respect of the destructive distillation of coal, or of the various processes for the purification of coal gas, or of the development of its lighting power, and at one time I hoped that one or two processes of purification, which have been suggested lately, might have formed my text for to-night. But in this I am disappointed. I do not think that these processes are in a sufficiently advanced state to allow of their being taken as a topic for a semi-popular lecture like that of this evening. Under these circumstances, I have been driven back to speak to you upon matters with which you are to some extent familiar, but I shall endeavour to treat of them in a way which possibly may not be devoid of interest, or, I hope, even of usefulness.

The subject "The Products of Combustion" is a very large one. It includes all the phenomena connected with the formation, nature, and influence of all those bodies which result from the burning of combustible matter. I propose, however, to restrict it to-night to the products of those bodies which are used for illuminating purposes. As it is in the process of combustion that such products are formed, and upon which they are dependent, a knowledge of what is involved in this process is necessary, and to this point, for a few moments as a preliminary, I propose to ask your attention.

When certain bodies are brought into very close proximity to each other, a combination, or a separation, or a re-arrangement of their constituents takes place. Such an action is called a chemical action; and under whatever circumstances such a chemical action takes place, an invariable result is observed—namely, a development of heat. Such heat is conceived to be due to the rapid motion of the molecules of which the bodies consist. The intensity of this heat varies; but when the motion is sufficiently rapid to give rise to the manifestation of light, combustion is said to occur. Now, the amount of heat which can be generated in any chemical action is fixed and definite, and it may be regarded, so to speak, as a potential property of the substance or substances which are undergoing change. It belongs to the matter in which the change is proceeding. But although this heat is an invariable quantity, and its amount cannot be altered by us under any circumstances whatever, the temperature obtained is not at all uniform; that is to to say, the temperature manifested in any given chemical action, or even in the same action under different circumstances, is by no means uniform. It is always an expression of the heat evolved, but it is itself variable, and is governed by circumstances. Let me endeavour to make this point clear by illustration. If I take a piece of iron, and permit to rust in moist air, a certain definite amount of heat is evolved by the chemical action which is going on between the iron and the oxygen of the air. The amount of this heat is dependent entirely on the amount of the iron and the amount of the oxygen which take part in the action. But if I take such a piece of iron as this [an iron bar], and expose it to moist air,

probably there would be no appreciable rise of temperature; I could not, even by the most delicate thermometer, recognize the amount of heat evolved in such a chemical process. But if I took the same weight of iron, and caused it to oxidize in the air under other circumstances, I might so develop the heat evolved in a short time, and in a small space, as to manifest itself, not only by means of a delicate thermometer, but in the visible shape of light. In this tube I have a quantity of metallic iron in a very fine state of division. The tube is sealed at both ends, and the iron is, therefore, out of contact with air. I shall break the tube, empty the contents on to this paper, and I think you will see by the incandescence which occurs with this iron, and possibly the inflammation of this piece of paper, that heat is evolved in this process of oxidising iron, and the process is identical in every respect with the one which goes on when I oxidize a piece of iron in moist air. [The experiment was performed.] You see here we have the iron made red hot, and the paper itself takes fire. That is only an illustration of what I was saying a moment ago, that the temperature may vary, although the quantity of heat would be the same. If the weight of iron which I had in the tube had been exposed to the air in the massive state, until the metal had been converted into oxide of iron, precisely the same amount of heat would have been obtained as in this case; but the light, or manifestation to us of heat in that action, is much greater in this case than in the other. A familiar example of this occurs to me. If we take a piece of wood—say a branch of a tree—and allow it to remain lying on the ground in the forest, it gradually decays. It may take weeks, or months, or possibly years, to decay and pass away into other combinations. If, however, we thrust it into a fire, it burns, giving out heat and light; but the amount of heat in each of those cases will be precisely the same for a given weight of wood.

The term "combustion" is usually restricted to those cases in which burning takes place with flame. In other words, those cases in which the burning bodies are in the gaseous condition. All flames are gaseous flames, and, whenever we have combustion taking place with inflammation, we are dealing with gaseous substances. Now, passing on a step further, and tracing the phenomena upwards, the temperature we can set up in a particular chemical action is an important point. Chemical actions are found to become more and more active as the temperature rises. Two bodies, which act upon each other slowly at ordinary temperatures, if heated up to a higher temperature before being brought into contact, will act upon each other much more energetically. Conversely, if we reduce the temperature of the substances which act upon each other, the activity of the chemical action is reduced in the same way, and it is probable that if we could obtain an infinitely low temperature no chemical action whatever would take place—that is to say, all chemical action might be prevented by lowering down to a sufficiently low extent the temperature of those bodies which would act on each other.

Now, if when a chemical action is once set up the motion of the molecules, or the intensity of the action, be sufficient to produce the phenomena of light, then combustion is said to take place. But this is a temperature which differs for different substances. All bodies do not take fire and burn at the same temperature. All bodies will not enter into combination with each other at the same starting-point. To illustrate this, I have here in this tube a substance which is a compound of the elements zinc, hydrogen, and carbon. It is called zinc-ethyl. This body is sealed up in a small glass bulb, out of contact with air. If it comes into contact with air, chemical action is immediately set up between the liquid and the air. At ordinary temperatures this body is said to be spontaneously inflammable. In other words, when it comes into contact with air, the chemical action is sufficiently intense to immediately raise the temperature up to the point at which light is manifested. If I break this bulb, as I do now, I think you will see that the substance will itself spontaneously inflame. It takes fire and burns the moment it comes in contact with the air, so that the initial temperature of chemical action, or of combustion in this case, must at any rate be lower than the temperature which we have round about us at the present time.

Now we go a step further. Taking another substance with which we are familiar—the elementary substance known as phosphorus. If I

take a small piece of phosphorus and place it on this plate, the phosphorus, unlike the body I have just used, does not take fire and burn by itself; but I can show you that the temperature at which it will take fire and energetically enter into combination with the oxygen of the air is a very low one—lower, in fact, than that of boiling water. If I take a tube containing a little water, and simply raise the water to the boiling point, and then touch the piece of phosphorus with the tube containing hot water, you will see the phosphorus itself will immediately take fire and burn in the air. I transfer the hot water to a cold tube, so that there may be no excess of heat in the tube itself, and, on touching the phosphorus with it, it immediately takes fire and burns. So that we have here a substance which we can cause to enter actively into combination with the air at an initial temperature higher than that of the previous substance. I now pass on to another. I take a few drops of a liquid well known, I expect, to every one present—bisulphide of carbon. If I take hot water and put the tube containing it in contact with the bisulphide of carbon, you will see it is unable to set the vapour or liquid of that substance alight. If, however, I take a temperature slightly higher than boiling water—such as I can get by heating this glass rod in the flame, I shall succeed in lighting the bisulphide. You see the tube with boiling water in it fails to set it on fire; evidently, therefore, it requires a higher temperature for its ignition than phosphorus. Now, I heat the glass rod to a point not very much in excess of the temperature of boiling water, and when I bring that in contact with the bisulphide it takes fire at once. This rod is far below the temperature of redness, but is higher than boiling water. Here again we have a difference in the initial point at which combustion takes place. I might go on and take coal gas. If I take a red hot wire I can ignite coal gas by means of the wire. I cannot ignite a candle at the same temperature at which I can ignite the coal gas. So I might go on and perform a whole series of experiments in which we should require a different temperature in each case.

Now, if at this temperature, which we may call the initial temperature of chemical action, a body enters into active union with a second body, with intensity enough to produce the phenomena of light, we have all the ordinary effects of combustion. It is possible, however, to get a kind of combustion in which we have not arrived at the temperature at which the substance enters into the most active union with the supporter of combustion; in other words, we can have an imperfect combustion, and I shall show you two illustrations of this. I have here a burner through which coal gas is streaming. If I take a piece of platinum foil, just warm it, and bring it over the gas, the platinum foil gets red hot, and keeps red hot, but it does not inflame the gas. The gas is streaming round it, but it is not inflamed. The temperature of the platinum is not high enough to inflame the gas, but it is high enough to keep up a slow imperfect combustion. If I raise the temperature of the platinum a little higher, the gas will take fire. I think I can do that by raising the platinum foil slightly higher. It will then get hotter, and the gas will be inflamed.

In concluding this point, I have one more interesting effect to show you, which can be illustrated very well by some gun cotton, which has been twisted into yarn in the form in which it is sometimes used in Austria. I take two pieces of the same length, and lay them side by side upon this board. I ignite one in the ordinary way with a flame, and I want you to observe the manner in which the gun cotton, lit by a flame, burns. It takes fire and burns with flame very rapidly down its whole length, giving out light. Now I will light the other one with a spark, which is considerably lower in its temperature than a flame, and you will see a considerable difference—this piece of gun cotton, of precisely the same composition, cannot burn in the same way when it is simply set fire to by a spark instead of a flame. I can prove to you it is really a question of temperature in the following way. If I take a piece of this gun cotton, as we had it in the latter case, burning with a slow fuse-like rapidity down its whole length, and hold it up while so burning, the heat, which is generated at its end, accumulates round the gun cotton about to be consumed; the temperature, therefore, is slightly higher, and it will elevate itself to that point at which it enters into combustion with flame. Taking the spark and setting fire to the gun cotton as before, it burns slowly. Then when I hold it up vertically, in a moment the temperature is raised sufficiently for it to burn with flame.

Now, the possibility of setting fire to many substances, and the apparent impossibility of setting fire to others, has led to a division of bodies into two classes—combustible and non-combustible; but such terms are purely arbitrary, and refer only to ordinary circumstances. Many bodies which do not ordinarily burn, may be made to do so if we only raise their temperature to a sufficient point, if we only obtain and maintain an initial temperature of sufficient intensity. A piece of wood we understand as a combustible body; a piece of sulphur, in like manner, we recognize as a combustible body, because we can set fire to it. A piece of iron, on the other hand, we do not usually regard as a combustible substance. Our fire-grates and pokers are usually made of iron, and we do not regard those materials as being combustible. At the same time they are so in reality if we only have a temperature sufficiently high. I will show you that this is the case with iron by an experiment. I am going to use a temperature which is simply higher than that ordinarily obtained in our grates, or even in the hottest wind furnace—the oxy-hydrogen blowpipe. I have here a quantity of iron nails, and those I am going to endeavour to burn as we ordinarily burn combustibles, and I think you will see they will burn well, with a considerable amount of brilliancy. This blowpipe is simply an apparatus whereby I can drive into a current of coal gas a current of oxygen; and in that way shall raise the temperature of the flame up to about 2500° C. At this temperature we obtain the combustion of these iron nails. A great part of the flame is due to the combination of the iron with the oxygen. It is evident, therefore, that the terms "combustible" and "supporters of combustion" are arbitrary only. Still, however, when all is said and done, we do arrive at a division of bodies into these two classes, for there are some bodies that we cannot make burn, and there are other bodies which, at a high temperature like this, we can make to burn. For instance, a piece of pumice is really an incombustible substance; there is no temperature at which we can make that substance enter into combination with the oxygen of the air and burn, so we simply widen our definition. We remove from it its arbitrary character, and make it general, when we deal with bodies like pumice, for example.

Familiar as men have always been with the phenomena of combustion, a true conception of its nature has only been arrived at within a very modern date, and by careful observation and experiment. Up to the latter part of the 18th century, what was known as the phlogistic theory of combustion, which took its rise 100 years earlier, was regarded as a sufficient explanation of the phenomena which were seen to occur. This theory, like many other erroneous theories which have held sway in the minds of men for a long period, died a very hard death. Generally speaking, the theory was this: The philosophers of that date believed that a combustible substance was made up of a material body, which they termed phlogiston, and of a second material substance which was left behind after the combustion had taken place. For example, they saw that wood burned, leaving a very small quantity of ash, and they said the wood had in burning lost the phlogiston, and the ash was left. The wood originally consisted of a compound of phlogiston with this ash. They saw again when a piece of metal was exposed to the air it was rusted, or when it was put into the fire it burned and left behind a kind of earth or calx, and they explained the fact by saying that the metal originally consisted of phlogiston, which it had lost during the process, and this calx or earth which it left behind. Now, much of this imperfect theory arose from the want of knowledge of the nature of air, and of the part which air takes in the support of all our ordinary combustions. They did not recognize the inter-dependence which exists between what we call combustibles and what we call supporters of combustion; and consequently, as soon as this was demonstrated by Lavoisier, then the phlogistic theory was doomed, the old philosophy was upset, and a newer and better, because a more true one, took its place. The principles upon which we now explain ordinary combustion at the present day are briefly these—that, first, in any chemical action, whether accompanied by the evolution of light or not, the sum of the weights of the bodies taking part in that action remains unaltered.

This is so important a matter that, with your permission, I shall illustrate it; for, although we acknowledge these facts constantly, sometimes if they are brought before us in the shape of a lucid experiment the matter

is thereby clenched in our memory, and we are no longer in any manner of doubt about it. Here I have a common oil flask which is capable of being closed with a sound tightly-fitting cork. I introduce into it a small piece of phosphorus. Phosphorus is kept under the surface of water on account of its inflammability. Therefore I dry it first in folds of blotting-paper; then I introduce it into the flask, and put the cork in as tightly as I dare without cracking the neck of the glass. Now I place this phosphorus and glass on a balance, which I bring into equilibrium. Taking the flask away and setting fire to the piece of phosphorus, it burns. There is an intense chemical action going on, the phosporus burns within the flask, and finally it will go out. When it has got cool I shall replace it on the balance, and I want you to observe that there has been no change whatever in the weight. It will now weigh precisely what it did before, showing that there has been no loss or gain in the weight. Therefore, in any chemical action, if we take into account the weight of the combustible and the body supporting combustion, it will be always the same amount. If I try it before it is quite cold, it will weigh lighter, but on allowing it to cool, and putting it into the balance, I think you will find if the cork is tight the equilibrium has not been destroyed. This is an exceedingly important experiment, and it is one of the kind which determined the abolition of the phlogistic theory.

The second point is, that the combustion is the evidence of a chemical action taking place between two or more bodies, the presence of each of which is necessary. The combustion of a piece of wood, for example, does not depend on the wood alone, but also upon something which can act upon the wood, and with which the wood can combine. In any case, we must have two or more substances before we get any chemical action or any combustion. The chemical action depends upon something beside the mere combustible, as may be shown by an experiment which has been constantly made, and which can be made at any moment one wishes. If I take a candle and cover it with a jar, you will see in a very short time that the candle goes out. Why? Not because there is no candle there; there is plenty of combustible matter, but the second substance, the oxygen of the air, which is necessary to the support of that candle flame, has been exhausted. Therefore, the process of combustion is an interdependent process, and depends as much on the supporter of combustion as on the combustible itself. In fact, our combustibles and supporters of combustion of to-day are, so to speak, simply accidental ones. The process of combustion goes on simply at the limit, the line of demarcation, where the two bodies which act upon each other come into contact, and it depends upon which of them is in excess, which of them for the time being becomes the supporter of combustion, or is the combustible itself. If we have air in excess, then air becomes our supporter of combustion. If, on the other hand, we had an atmosphere of coal gas, the bodies which we now call combustible would cease to burn in it, and we should have to look to those bodies which at the present time we call supporters of combustion in order to get any illumination at all. Now, I can show this relationship between supporters of combustion and combustibles themselves in two or three ways. I take here, first of all, a jet of hydrogen gas burning at the end of this tube. I introduce this into a bottle which contains oxygen gas. The hydrogen continues to burn, and burns with rather increased brilliancy in the bottle of oxygen gas. It is an ordinary case of a combustible and supporter of combustion. Now I propose to reverse the matter entirely, and to burn a jet of oxygen in an atmosphere of hydrogen. Here I have a vessel of hydrogen gas, and coming through this tube I have a jet of oxygen. The oxygen gas will not burn, as I can show you, by holding a light to it; it causes the taper to burn more brilliantly, but I cannot set fire to the gas itself. Here, then, in this hydrogen I have a substance which a moment ago was burning itself. If I take it and set a light to the gas, and introduce the oxygen jet into the atmosphere of hydrogen, the oxygen burns with a considerable amount of brilliancy. We have, therefore, simply reversed our usual process. Why has this been the case? Because we have, in the first case, a large excess of oxygen and a small quantity of hydrogen, and in the latter case a large quantity of hydrogen and a small quantity of oxygen. All our ordinary gas flames burn, as you are aware,

in air; but we can, if we simply make a suitable arrangement, cause air to burn in an atmosphere of coal gas. Here is an apparatus arranged for this purpose. Into the base of this glass vessel some coal gas is conducted. Through the centre of the cork there passes a tube, which is in free communication with the external air. I can put up through the cork this taper. Through the glass tube I am conveying coal gas, and in the ordinary way I can set fire to the coal gas at the top, where it burns. But we have now going in through the open tube a little jet of air, and I can set fire to that air within the atmosphere of coal gas. I have simply surrounded the flame of air with a coil of platinum wire, in order that it may be more obvious at a distance. The flame burns with a non-luminous flame, very much like that of a Bunsen burner, but by surrounding it with a small coil of platinum wire, you can see the heat produced by the flame.

First we have, then, the non-alteration of weight; secondly, the relation between the combustible and the supporter of combustion; and, thirdly, we find that the weight of the products formed is greater—rather, I should say, the weight of the products which are formed is a larger one than the weight of the original substance which is burning. If we burn a pound of candles, and weigh the products which are obtained, we get an increase of weight. We do not ordinarily see this. The candles disappear, oil, coal, and coal gas disappear; but it is because we have not arranged the circumstances in such a way that we can see the fact. An experiment will be fitted up with this balance, in which you shall see that such is the case. A flame of a candle is made to burn in this vessel. The products of combustion are passed through this tube, and through the little globe which you see filled with fragments of a white substance, and finally up through the glass chimney. The white substance is placed here with a view to retaining and absorbing the products of the combustion of the flame which we have here. If we hang this on the balance, I think you will find that, although the combustible gets less and less in volume, and, consequently, in weight, that the whole apparatus gets heavier and heavier, because the combustible, *plus* the body which unites with it, is of greater weight than the combustible alone. We will first make the weight-pan slightly heavier, and you will see, long before the lecture is concluded, that the balance will have turned.

The nature of the products which we obtain from combustion varies. They may be either solid, liquid, or gaseous; and I have now, in going on with my story, to call your attention to the composition of the substances which we usually utilize for illuminating purposes, because it will depend upon the composition of these bodies what is the nature of the product or products which we obtain. These bodies consist essentially, all of them, without exception—all ordinary bodies used for illuminating purposes in which chemical action occurs—of compounds of carbon and hydrogen. A few of them, and only a few of them, contain oxygen, and the presence of other elements is rare, and may be regarded, so far as our present purpose is concerned, as accidental. Atmospheric air is the universal supporter of combustion for all ordinary processes of this nature; the air which we have to breathe, which exists as a mantle around the whole globe, forms the supporter of combustion for all such bodies. We should therefore expect that the products of any ordinary combustion would be compounds formed between the substances entering into the composition of the combustible matter and the constituents, either one or more, of atmospheric air. I have here a table representing the composition of air, both by volume and by weight:—

Composition of Atmospheric Air.

	Volume.	Weight.
Nitrogen	79·19	76·99
Oxygen	20·81	23·01
Total	100·00	100·00
Aqueous vapour (average)	1·40	0·87
Carbonic acid	0·04	0·06

Ammonia about one part per million.

The air may be regarded as a mixture of nitrogen and oxygen, in the proportion, in round numbers, of one-fifth of oxygen and four-fifths of nitrogen. But all ordinary air, the air which we find wherever we go, either at the top of a mountain or down in a valley, is always found to contain other bodies, and these bodies, some of them, are written here. Aqueous vapour is always present, carbonic acid also is always present in about this quantity—not invariably so, but very near it—and ammonia, which is rather more variable. Now, of the two principal substances, this nitrogen is an exceedingly inert substance. It is with the greatest difficulty that it can be brought into union with other bodies directly, and in all processes of ordinary combustion the nitrogen remains entirely unacted upon. It takes no part whatever in such processes. On the other hand, the oxygen is an exceedingly energetic supporter of chemical action, and it is mainly—in fact, entirely by virtue of this oxygen, which occurs in air, that air possesses its property of supporting combustion. Hence we should look for the products of combustion to be compounds of the constituents of the combustible body with this substance—oxygen gas. Now such is, in fact, the case. The bodies which burn in an excess of air, as a general rule, form those compounds which contain the largest proportion of oxygen with which they can unite. The carbon which exists in all our ordinary fuels burns to carbonic acid, which is the compound of carbon and oxygen containing the largest proportion of carbon. The hydrogen in our illuminating fuels burns to form water, and water contains the highest amount of oxygen which we can unite with hydrogen under ordinary circumstances. Now the quantities of the products which we can form will depend on the weight of carbon and hydrogen which can be consumed in a given time. There is no loss whatever in these weights. Therefore the weights will be directly proportionate to the amounts which we are able to consume. If we take 1 lb. of carbon, it will unite with 2·6 lbs. of oxygen, and will, therefore, form 3·6 lbs. of carbonic acid gas; 1 lb. of hydrogen will unite with 8 lbs. of oxygen, and will form therewith 9 lbs. of water. Now these quantities of oxygen will be found in the following quantities of air. Air consists of about one-fifth of its volume of oxygen, and the 2·6 lbs. of oxygen which are required for the combustion of 1 lb. of carbon, will be found in 11·6 lbs. of air, or 150 cubic feet. In other words, 1 lb. of carbon will require all the oxygen contained in 150 cubic feet. The 8 lbs. of oxygen required to burn 1 lb. of hydrogen are contained in 34·8 lbs. of air, or 452 cubic feet—that is to say, there will be required for the combustion of 1 lb. of hydrogen the amount of oxygen contained in 452 cubic feet.

With these remarks I may go on at once to the consideration of the combustion of four of our principal illuminating fuels. Two of them I shall deal with a little in detail; and, with regard to the others, I shall give you the position which they occupy relatively to the other two. These four will be—first, sperm in the form of candles; second, sperm or colza oil; third, paraffin oil; and, fourth, coal gas. In spermaceti we have a compound of carbon, hydrogen, and oxygen. One pound of spermaceti contains ·8 of carbon, ·13 of hydrogen, and ·06 of oxygen. If we burn a sperm candle at the rate of 120 grains per hour, the candle will give, per hour, ·41 of a cubic foot of carbonic acid—not quite half a foot. If we take 16 candles burning for an hour, 6·5 cubic feet of carbonic acid are the product of the burning of the carbon contained in this quantity of spermaceti. If we consider the hydrogen which is contained in spermaceti, and regard the amount of water which is formed, we shall find that 120 grains of spermaceti burnt as in an ordinary candle will give 145 grains of water, 16 candles in one hour will give about 2320 grains, or 4½ oz. of water. To put it in another way—a sperm candle, which may be regarded as weighing about 2¾ oz., will give in its combustion 3½ oz. of water. This water will remain suspended in the air as aqueous vapour until the air is saturated. The amount of water which can be suspended in ordinary air is a question of temperature, and the amount becomes greater as the temperature is higher. But when the limit is reached, when the air contains as much water as it can take up at a given temperature, any further quantity must be deposited.

If we pass from candles to sperm oil, we find that colza oil and sperm oil, in respect of the amounts of carbonic acid and of water which

they give, light for light, will be about equal. Paraffin oil is intermediate; it does not give off so much carbonic acid as do candles, but it gives off more, light for light, than coal gas. So also with the amount of water. The order in which these combustibles vitiate the atmosphere may be taken, as regards carbonic acid and water, thus: Light for light, coal gas, the lowest, represented by 1; paraffin oil, the next, 1·5; sperm candles, the worst, represented by 2—that is to say, the amount of carbonic acid and water given off by the combustion of sperm candles, light for light, compared with gas, would be about twice as much as that of coal gas.

Now, for coal gas itself. If you take a specimen of coal gas which has a specific gravity one half that of air, or ·5, a cubic foot of such gas contains about half its weight of carbon; and, if this cubic foot of gas be burnt, it will give a little more than half a cubic foot of carbonic acid. The precise number is ·55, or, in weight, 488 grains. With regard to the hydrogen, a cubic foot of coal gas, of ·5 specific gravity, contains about 41 grains of hydrogen, and this hydrogen in burning will produce 372 grains of water. If we regard the quantity of air necessary to supply the requisite quantity of oxygen to a cubic foot of gas, it lies between 5 and 6 feet of air. For every cubic foot of gas burnt, we require the entire oxygen of between 5 and 6 cubic feet of air, and this will give half a cubic foot of carbonic acid as a result. If we compare this with the amount of carbonic acid given off by respiration, we obtain the following relation: If 5 cubic feet of gas are burnt in one hour, we get from them 2·7 feet or rather more, carbonic acid. If an adult human being breathes for the same period of time he exhales with his breath about ·7 cubic foot of carbonic acid, about one-fourth of that given off by a gas-burner burning 5 cubic feet of gas. Now the quantities of carbonic acid and water given off by one cubic foot, or even 5 cubic feet, appear relatively small; but, if we come to deal with the quantity of gas used, say, in London annually, the amounts are somewhat astonishing—the figures are really startling. The quantity of gas consumed in London annually may be taken approximately, at present, at about 15 millions of cubic feet. The amount of carbonic acid given off during a year by the combustion of those 15 millions of cubic feet amounts to 433,000 tons. That quantity is discharged into the atmosphere by the combustion of the coal gas consumed in London, an amount which contains as much carbon as would be found in the wood growing in a forest of considerable dimensions. The amount of water produced by the combustion of this quantity of coal gas is 360,000 tons, or 80 million gallons. You will have on Thursday, I believe, an opportunity of seeing one of the largest, if not the largest gasholder-tank in London, at the Phœnix works at Kennington. That gasholder-tank, supposing it had no internal cone, and were perfectly flat at the bottom, would hold—Mr. Woodall, your President, was good enough to calculate the figure for me—10 million gallons of water, if filled to the brim. You might empty that tank and fill it eight times over in a year with the water produced by the burning of the coal gas consumed in the Metropolis during that time.

Now we have to consider the effect of these results upon the vitiation of the atmosphere. The amount of carbonic acid in the air, ordinary normal air, is ·04 per cent.; in other words, 4 volumes of carbonic acid are contained in 10,000 volumes of air. Now, if we increase this proportion to ·06, we arrive at what may be set down as the healthy limit, and we ought not to go beyond it; in other words, 6 volumes of carbonic acid in 10,000 of air. As a matter of fact, even in our best buildings it is found under present circumstances almost impossible to keep the carbonic acid even as low as that, and for the purpose of calculation I am going to take as much as ·1. Now, ·1 per cent., or 10 volumes in 10,000 cubic feet, means this—that you may introduce into 10,000 cubic feet of air the difference between 4 cubic feet and 10 cubic feet before you arrive at this amount of vitiation. In other words, you may discharge into 10,000 cubic feet of air 6 cubic feet of carbonic acid. You then reach the limit, which, as I say, is really beyond a healthy limit; for an atmosphere containing ·1 of carbonic acid is a bad atmosphere, and anything beyond it is excessively bad.

Now 5 cubic feet of gas burnt will give off 2·75 cubic feet of carbonic acid, and the amount of air into which this amount of carbonic acid may be discharged, in order not to exceed the limit of ·1 per cent., will be 4500 cubic feet; in other words, for the combustion of 5 cubic feet of gas we

require the special use of 4500 cubic feet of air, supposing the air is not changed. One adult human being discharges by respiration ·7 cubic foot of carbonic acid per hour, and the quantity of air which he will require the use of, in order not to exceed the limit of ·1 per cent., will be 1166 feet. So that if we start with a room of 5660 cubic feet capacity, then we may allow a gas-burner to consume 5 feet of gas in that space, and an adult human being to breathe for one hour, before we reach the limit. But when we have once reached that point, where all the air is so far vitiated, it must either be renewed entirely or the vitiating influence must be put an end to.

Now take the room in which we are assembled. This large room contains, in round numbers, 60,000 cubic feet of air. The external air may be taken to have the normal amount of carbonic acid in it of ·04. We may, then, vitiate with impunity, that is without passing beyond this limit of ·1 per cent. of carbonic acid, up to that extent. Thus we may introduce into this room 36 cubic feet of carbonic acid before we shall reach the limit of ·1 per cent., supposing the air in the room not to be changed. Now, if 10 gas-burners, each burning 5 cubic feet of gas, were burnt in this room for one hour, and 10 men remained in the room for the same period, these 36 cubic feet would be given off; in other words, 10 gas-burners burning 5 cubic feet each, and 10 men breathing for an hour, would bring up the proportion of carbonic acid in this room to ·1 per cent. or outside the limit of anything which can be conceived to be a healthy state of things. Now it is not at all an unusual circumstance for 25 gas-burners and for 100 men, as we are to-night, to be assembled in such a room, and if we take these figures, we shall require for combustion the use of 112,500 cubic feet per hour, and for respiration 116,500 cubic feet—both together being 229,000 cubic feet of air required for these purposes alone—in order that we shall not exceed that limit. In other words, the entire contents of this room must be changed four times in the hour to keep down the proportion of carbonic acid to the limit of ·1 per cent., or 169,000 cubic feet of air must pass into and out of the room every hour in order that this shall not be the case. Now any current of air that travels at the rate of more than 16 inches per second is a draught; and it is obvious, from this fact, that the air in this room cannot be changed by any such forcible means. Direct currents of incoming and outgoing air do not, by any means, represent the amount of change going on. There is a process of diffusion taking place constantly through the walls and the ceiling and floors of our dwellings, and this process, although not recognized, and although continuing its action in silence, is an exceedingly important one, and is really a saving process for us who have to live occasionally in rooms not artificially ventilated. The process of diffusion may be stated to consist in the tendency which all gases have to become intimately and permanently mixed; and the process goes on through porous substances, and through other substances which we do not usually regard as porous. I may illustrate the matter to you by a very simple experiment. I have here a tube closed at the upper end by a block of gypsum or plaster of Paris a little more than a quarter of an inch thick, and this glass tube is in communication with this upper receiver. I shall fill the tube with hydrogen gas, and I will place the lower end under the surface of some coloured water. The inner part of the tube will be filled with hydrogen, outside will be air. The hydrogen will diffuse or tend to pass through the pores of the plug into the surrounding air, but the hydrogen will pass through faster than the air enters, and the consequence will be that a reduction of pressure will be caused inside the tube. If this be so, the column of water will rise, which will show you the effect. It is now filled with hydrogen gas; I immerse it in the coloured water; we will leave it for a few moments, when you will find the coloured water will rise in the tube. This means that there must be less pressure inside the tube than there is on the surface of the water; and this is due to the fact that the hydrogen is escaping through the pores of the plug faster than the air is entering. This is an illustration of the same process that is going on through our walls and ceilings.

Now the rate of diffusion varies inversely as the square root of the density. Its rate is dependent, therefore, on the density, so that any means by which we can alter the density of our air or gas will produce an

effect on its diffusion. If you have two gases, one on one side of the porous plug, and one on the other, the greater the difference in the density, the greater will be the speed of diffusion. Now there are two things which tend to alter the density of air within our buildings; those two are—first, an alteration in the composition which takes place in the air; and, secondly, the elevation of the temperature. Now the alteration in the composition comes from the discharge into air of water and of carbonic acid; but the alteration is small, and may, as far as regards its influence or diffusion, be neglected. The elevation of temperature comes from the heat of our combustible fuels, and also from the heat of our bodies, and the greater the difference of temperature which we can get between the air inside and out, the greater will be the speed of this diffusion. But we shall find that as the rate of diffusion does not increase proportionately to the vitiation, we shall gradually overtake the rate at which it is taking place. Consequently we shall, after a short time, arrive at a limit beyond which the process of diffusion will be unable to help us, and from which point we shall begin to vitiate our air more and more. The heating effect of gas and of sperm oil is about equal, light for light; the heating effect of paraffin oil and candles is about the same, but greater than coal gas and sperm oil. Of the materials which can be classed as ordinary building materials, those which permit the diffusion to go on most rapidly are: First, the material which is occasionally used, I am afraid, in the building of some of the houses in the suburbs—I refer to dried mud. That is a substance through which diffusion takes place with the greatest ease, much greater than through ordinary bricks or stones. Next to mud come bricks. Bricks allow diffusion to go on with a very considerable amount of rapidity and ease, almost as easily—easier in some cases—than through this plug of gypsum. You can see the ease with which the hydrogen finds its way through by the height to which the water has risen, representing 16 or 18 inches water pressure. Next to brick we have limestone. And, lastly, sandstone. This is the order in which you can take building materials. I would state here that, in my opinion, it is high time that architects and builders should be called upon to recognize that it is absolutely necessary to ventilate not only large buildings, but every room in a house in which persons may have to remain for some time, more especially those in which artificial illumination is used. If it were not for this process of diffusion, the matter would long ago have become imperative, because there would hardly be a room in which, after a little time, it would be possible to live; but so long as this condition is not arrived at, all concerned seem willing to allow things to remain much as they are.

The process of diffusion, although it has been a saving element in this matter, has been, at the same time, rather a snare, because when we lose its influence we find it becomes absolutely imperative to get air in some other way. When we descend a coal mine, we have no diffusion whatever to help us, and all the air which is required there for the respiration of men employed, and for the combustion of their illuminating fuels, must be sent directly down the shaft; and what is the consequence? that an enormous quantity is found to be required, much more than is conceived to be necessary on the surface—much more than is necessary, in fact. As much, in some of the northern pits, as 350,000 cubic feet of air is sent down per minute. This is needed, because they are not able to rely upon any other source below.

The air of a room cannot be conveniently changed more frequently than from three to four times per hour, and it should be seen always that the vitiating influence is not in excess of this rate of diffusion. Further, the oppressiveness of a room, the effect which it has of producing headache and nausea, is not due only to the presence of carbonic acid and moisture. You may go into a soda-water manufactory, in which there is a very much larger amount of carbonic acid in the air than in any of our rooms which are even imperfectly ventilated, and you do not suffer in the same way as you do from remaining in an ordinary ill-ventilated room. The reason of that greater oppressiveness of our rooms is due to the presence, I think, of organic matter. Now, this organic matter is exhaled in the breath, and is given off by all our illuminating fuels; and it is this organic matter in the air which produces the feeling of depression which we all feel on remaining for some time in a room which is ill-ventilated. The amount of

unburnt carbon products given off by coal gas, for example, is very large, and it is very probable that those burners which give out the greatest amount of light really give out the greatest amount of unburnt carbon products into the air. The amount of organic matter in the air will be proportionate to the amount of carbonic acid discharged either by respiration or combustion, and hence it may fairly be taken as a measure of the badness of the air.

I have purposely omitted, up to this point, all mention of the sulphur which coal gas contains, and which, as an illuminating agent, is peculiar in this respect. I propose, with your permission, to detain you a few moments, while I deal with the subject of sulphur in coal gas. In any considerations of the vitiation of air by the products of the combustion of coal gas, this sulphur must be taken into account. It occurs in the gas, in some form of combination, as most of you know, I apprehend, in some other form than of sulphuretted hydrogen. Undoubtedly, some part of it occurs there as bisulphide of carbon; but I do not think, by any means, that the amount of bisulphide of carbon accounts for the whole of the sulphur. In some cases, I believe, it accounts for a very small portion of it. But whatever form the sulphur may be in, when the gas is burnt, that sulphur burns into sulphurous acid. There is a very considerable difference of opinion as to the precise state in which the sulphur is introduced into the air, some gentlemen affirming that it is sulphurous acid, others that it is immediately oxidised to sulphuric acid, and some, indeed, maintain that sulphuric acid is the product of the combustion of sulphur when it is burnt at the same time with hydrogen; that is to say, that when water is formed at the same time, sulphuric acid results, and not sulphurous acid. My own decided opinion is that the sulphur is at first all burnt to sulphurous acid, that then a certain portion of this sulphurous acid is oxidized into sulphuric acid, and that the amount so oxidized depends upon circumstances; but that, given a sufficient length of time, the whole of the sulphurous acid will be oxidized into sulphuric acid. Now as to the circumstances. If the sulphurous acid is kept hot in the presence of moisture, then oxidization goes on more rapidly; if it be cooled down almost immediately after it is formed, the action is very slow, and within any reasonable time it will be found impossible to entirely oxidise the whole of the sulphurous acid into sulphuric acid. Then, secondly, if the sulphurous acid meets with a base or with an easily-oxidizable substance with which it can unite, it undergoes oxidization much more readily than if it remains in the state of free acid. There is no doubt that metal fittings, if used in contact with the products of combustion from coal gas, do become corroded with sulphuric acid. Here is some sulphate of zinc, which I myself obtained by burning London coal gas under a small zinc hood. You can also obtain sulphate of copper by burning coal gas, as most of us chemists know, under the surface of a copper water-bath. There is no doubt whatever of this, but then we are dealing with this circumstance which I have mentioned; we have an easily-oxidizable substance present, a body which can unite with sulphurous acid and form a salt, and, under these circumstances, oxidation goes on very much more readily than otherwise. Thirdly, if sulphurous acid, water, and air be absorbed into a porous body, then oxidation goes on more rapidly, because the air and the sulphurous acid and the water are brought into closer contact, and I believe this is why leather bindings and leather goods generally are always brought so prominently to the front, with regard to the matter of contamination by the combustion of the sulphur compounds in coal gas. It is due to the fact that you are dealing with a very porous substance, and the same thing being repeated again and again, you do in time get a certain amount of damage produced; but that this damage is anything like what is generally represented, I beg leave very much to doubt. From my own experiments, I believe that, under ordinary circumstances, considerably less than one-half of the sulphurous acid produced by the combustion of coal gas is oxidized in any reasonable time into sulphuric acid, and in this I am supported by several gentlemen, who, not being connected with the coal gas industry, are, nevertheless, thoroughly acquainted with the behaviour of sulphurous acid when used in the manufacture of alkali.

With regard to the question of sulphur in gas. You remember we

concluded a short time ago that the air of a room must be constantly changed, or we could not exist, and that the change must be going on several times in each hour; the whole atmosphere must be changed generally more than three times in each hour. Now, supposing sulphur is burned into sulphurous acid, and that it exists for even a part of an hour as such in the air uncondensed, it will come under the ventilating effect, and will undergo removal just in the same way as the aqueous vapour or the carbonic acid present in the air. If one-half of the sulphur remains in the gaseous condition for only one hour, it will be entirely removed within that period. I believe most of the ordinary effects which are attributed to the presence of sulphur in coal gas, and the damage that it does, are quite easily accounted for by other things. I believe the constant drying and wetting, coupled with the elevation of temperature, and the presence of carbonic acid—effects which result from all illuminating fuels alike—are quite competent to account for the greater amount of the damage which is represented as being solely due to the presence of sulphur. If we regard the absolute quantity, the figures become exceedingly minute, even if you have 20 grains of sulphur in 100 feet of gas. Supposing it to exist in the form of bisulphide of carbon, here is such a quantity of bisulphide containing 20 grains of sulphur. The quantity in this little tube, about an inch of it, represents 20 grains of sulphur, or the amount which we may take as being present in 100 cubic feet of our London gas. Now, I could, if I had time, burn the whole of this quantity at once, and you would have all the sulphurous acid from it discharged into the air, and that would represent the sulphurous acid from 100 cubic feet, but I believe it would be impossible for you to find out the sulphurous acid, although it is there. Undoubtedly it is there, but it is diluted to such an extent that you could not find it by any ordinary test. If 20 grains of sulphur burn, they form 40 grains of sulphurous acid; a cubic foot of sulphurous acid would weigh 1184 grains. Now the thirtieth part of a cubic foot of sulphurous acid is produced by 20 grains of sulphur, or the amount in 100 cubic feet of gas, and I may say that such a quantity in this room, supposing the room to contain approximately 60,000 cubic feet, would be represented by the block I hold in my hand, about 3¼ inch cube, and which, if diffused through the entire room, would amount to about one-half part per million in volume, or about ·000001 per cent. in weight. If a proper arrangement were adopted to carry off the products of combustion, there would be no more complaints of sulphurous acid, and I believe that proper care ought always to be taken that coal gas ought not to be burnt, in anything like quantity, without such arrangements being adopted. If this were done, all danger from damage by sulphur, even if it existed in greater quantity than it does, would be at an end, but I expect it would be found, supposing you could find out how to take the whole of the sulphur out, the complaint of the damaging effects would continue for some time just the same.

I may say, with regard to the per centage, it has been found that in the Manchester atmosphere, over a range of four miles, the amount of sulphur present normally in the air would be about equal to the quantity which would be formed in this room by the presence in it of this amount of sulphurous acid; consequently, the whole atmosphere of that town we should expect to be doing damage by sulphur. If we regard the amount of coal burnt here in London, 8,000,000 tons per annum, and if we take that coal to contain 1 per cent. of sulphur which is burnt—whether in the form in which you send it into houses in gas, or in furnaces, or in grates, it is burnt in some way—and which is a low average, we shall have 80,000 tons of sulphur thrown into the air in the form of sulphurous acid, and if that is calculated into oil of vitriol, it will amount in one year to 240,000 tons of oil of vitriol sent into the atmosphere of London alone by the combustion of coal.

Now, gentlemen, I have to bring these remarks to a close. Engineers of gas-works are, by their knowledge and skill, constantly being called upon to deal with problems which are ever increasing in variety and breadth and I do not think this tendency will cease until, not only is the gas produced and distributed in the best possible manner, but such means adopted as will produce the greatest effect with the least possible inconvenience.

The PRESIDENT proposed a vote of thanks to Mr. Wills for his interesting and instructive lecture, which was carried unanimously.

WEDNESDAY, JUNE 19.

SOME OF THE OBSTACLES BY WHICH THE APPLICATION OF GAS FOR HEATING PURPOSES IS RETARDED.

By Mr. T. TRAVERS (Cork).

In the papers presented to this Association it is natural to expect some original matter. To the credit of the members, a considerable amount of it has been furnished from time to time; but, in the present instance, the writer fears, not only will the lack of it be conspicuous, but he feels his difficulty increased when, on looking over the Transactions of the Society, he finds that the subject of gas for heating purposes has been treated of by some of the ablest of the members. Notwithstanding this, he believes it to be of such importance that an opportunity for again discussing it should not be allowed to pass by.

Whether we consider, either from a scientific or an economical point of view, the advantages to be gained by the use of combustible gas for fuel, as compared with heat produced from solid material, we must consider it to be a matter of some surprise that more attention is not directed to it, and that greater efforts are not made to bring it into general use.

That this subject is of no small moment to the public at large must be seen from the consideration of the great extent to which the production of heat enters into the necessities of every-day life. Besides the quantity of material which is usefully employed, an amount which may seem fabulous to many is annually wasted of that product, and the article thus wasted is that which has tended more than any other to make this country pre-eminent, in a manufacturing point of view.

If I say that in the production of heat from coal, as it is generally used, there is a loss of 40 per cent. of its thermal value, I am giving a very low estimate indeed; yet even this will represent some millions of tons in the year wasted in the following ways:—By imperfect combustion, by the escape of volatile gases, and by cinders. So that not only in the volumes of smoke which are to be seen hourly forming dark clouds over our thickly-populated towns, but in the invisible gases possessing high calorific power, and which are being constantly emitted from every chimney, you have a perpetual waste of power. Even in the *débris* which in cartloads is removed from our refuse-pits we suffer another loss, from all of which a gaseous fuel would be perfectly free; and this waste, it must be remarked, is going on at a time when the utilization of power now going to waste is daily becoming more important; for, by the measure of our success in this respect will we be able to hold our own in the competition now going on among industrial nations.

In our time we have made wonderful strides in other respects. An artizan can now travel from one end of the land to the other at a speed, and in a style and manner, that the nobility could not command half a century ago. A monarch would have freely given a portion of his kingdom for the power which the electric telegraph now-a-days places within the easy reach of every man. Then look at the water supply to be found in abundance and purity, not only in every house, but in every room, if required; thus rendering obsolete the rude pump and the draw-well, which, in times gone by, were frequently the pestilential sources of disease. Yet, in one respect, we remain comparatively unchanged—that is in the production of heat. Our forefathers—to go back to a very long period since—made fires on the same principle as we do. When heat is required

in our parlours or drawing-rooms, we have, so to speak, to make it there; and this very rude and by no means clean process must be carried on at the expense of damage, more or less, to the furniture and decorations.

If, in addition to the waste, we add the labour and time lost in the production of fuel from solid material, we have another, and a not unimportant, item of loss.

That the present system of producing heat should be discontinued is not only in accordance with the spirit of the age, but we as a body are interested in the success of the change.

On the one hand, it is satisfactory to note that efforts are being made every day to alter this state of things; on the other, as they have not met with a success in proportion to the importance of the undertaking, it is reasonable to conclude that there are some obstacles in the way; if so, an inquiry into them ought to lead to a good result.

Unquestionably, there exists a wide-spread prejudice against the use of gas for cooking. In nine cases out of ten, when you speak of it, you are met with an almost stereotyped observation: "It is unwholesome, it contaminates the viands;" and this idea prevails very much among the ladies, particularly that portion of them who may be said to rule the roast, and it is no easy matter to eradicate it. However, we feel it is not a difficulty of so serious a character but that it may be got over by time, perseverance, and a few practical experiments. Of this we have had an illustration in Cork during the present year.

A lady from South Kensington was engaged to give lectures on cookery. Previously to her arrival we were making efforts to introduce cooking by gas, but were met with the usual remark as to its poisonous character, &c. When the arrangements were being made for the lectures, we applied to the Committee, and offered to supply a range and gas free of cost. At first this was declined, and some of the ladies rejoiced at their supposed escape from the horrible gas. On the arrival of the lady lecturer, she was made acquainted with the gas company's offer, which she immediately accepted, and put aside the coal range. In order to have satisfactory evidence of the working of the apparatus, we laid a special service, fixed a meter with a pressure-gauge attached, enabling us, therefore, to make observations during the month which the lectures and demonstrations occupied.

I may tell you that there was an ample supply for all purposes at 6-10ths pressure.

There was no remark made on the so-called contamination of the viands. They were all prepared in the presence of the ladies who attended the lectures, and the numbers were very large. There could be mistake as to the *modus operandi*, and the obnoxious (?) gas was used in the preparation of every one of the dishes. The ladies were not only satisfied, but surprised, and, in justice to them, I must say that in many instances they took practical steps to convince the doubting gentlemen at home. But one lady, forsooth, was found to understand the reason of the success of the experiment better than any one else. Within the hearing of the writer, she informed her neighbours that the success was due to the fact that the gas company were supplying the gas-stove with a special gas; It was not at all the same gas as was in general use in the city.

At the conclusion of the lectures, not only had we the satisfaction of knowing that the prejudice had been completely dissipated, but the lady lecturer assured her audience that she with ease produced results by the use of the gas-cooking stove, which, to say the least, would have been very difficult to achieve with the ordinary process, and she gave a testimonial to that effect as follows, which we were able to publish in the local papers. She wrote:—

"I have the greatest pleasure in testifying to the cleanliness, comfort, and convenience of your gas-stoves. I feel sure that when the hot weather comes you will have a great demand for them from those ladies who attended my cooking classes this last month. The oven heated by gas is, of course, far more satisfactory than when heated in any other manner, as you can regulate the temperature according to your wishes, and, moreover, it is heated from the bottom, which is a great advantage."

Before leaving this point, I must remark that, if you are anxious to

make gas cooking a success, it will not be sufficient to convince the lady of the house. You must by no means omit from your attentions our friend the cook, in the kitchen. Her good opinion must be obtained, and the new machine must not be introduced without her full concurrence and approval. I know one lady, who had the imprudence to order a gas-range without having consulted the head of the *cuisine* department. It was with difficulty she was able to secure a favourable reception for the intruder. Another difficulty from the same source, and one not easy to deal with, is the extravagant use of gas by servants. I by no means sympathize with the feelings that would render a gas company's official indifferent to the quantity of gas used extravagantly in this way. It must be remembered that gas for fuel, compared with coal, is not so cheap as gas for light, when compared with other sources of artificial light; and, therefore, if we desire to popularize the use of heating gas, it is for us to assist the consumers to use it with advantage and economy. A gentleman for whom we fixed a range was anxious to find out the cost of gas as fuel. One day he took the register of the meter, and again on that day week, when he found that the consumption was over 500 feet. He at once concluded that this was an extravagant arrangement, and gave notice to have the gas-range disconnected. Before doing so, he acceded to our request to have another trial made under the supervision of one of the company's officers, and the result was that 300 feet were found to be ample for the performance of the same amount of work.

In the first instance, the gas was permitted, like a coal fire, to burn away at times when it was not required. When such is the case, you will have an unfavourable opinion created as to the comparative cost of coal and gas, so that in the previously formed habits of servants, you have another difficulty to contend with, and one, as we have said, not easy to overcome.

We would be wanting in the candour necessary for the wholesome discussion of this subject, if we did not admit that some of the objections thus offered are not altogether groundless, and this arises from the malconstruction of many of the stoves supplied to consumers. Not only is the amount of heat imparted out of proportion to the quantity of gas supplied, but, owing to imperfect combustion, a most disagreeable smell is given out, quite sufficient to lead to the impression that the viands are becoming tainted.

You have a large number of makers of gas-heating apparatus, each differing in his mode of construction. The improvements said to be made by one are ignored by the others, some resting their claim on novelty of the external design; others on substantial workmanship; more on being able to supply very cheap, but often very flimsy materials; but, in this attention to secondary matters, the true principles on which a stove should be constructed are lost sight of, and therefore it is, when stoves of this class are put in the hands of a practical person, such as an experienced cook, the arrangements are found to be so badly made that the constructors display an absence of the elementary principles to be observed in the operations of every well-constructed piece of apparatus. For example, you are informed by one maker that his range will roast; but, on applying the thermometer to it, you will find that at the outside you will not have more than 150° Fahr. Instead of roasting, you have meat only browned, and no more. What has become of the extra heat? In fact, as in the case of the coal, it has passed up the chimney. In the maker's anxiety to convey off the products of combustion, he attaches a pipe out of proportion to the necessities of the case. While it is right to take off the products of combustion, it can be done without the loss of 100° of the heat, and this I have proved. Other makers will give you a stove in which you will get the heat for roasting, but you will not be able to get it to work under from 8 to 10-10ths pressure. Let the supply stop under this, and, if you open the stove-door, you will have a slight explosion, caused by the firing back of the mixture of air and gas. This slight explosion, although, no doubt, harmless in itself, has proved fatal to the reputation of the apparatus, and the fault, so common in air-burners, when it occurs in the gas-stoves, produces a very disagreeable smell.

However anxious we may be for the success of heating gas, yet to be obliged to sustain in the mains 10 to 11-10ths pressure, is, perhaps, more

than the majority would be able to afford, and it is more than ought to be necessary; for I hold that good results can be obtained with properly constructed stoves at 6-10ths pressure, and that, too, without the danger and annoyance of the light firing back, as it is called.

You have again stoves constructed with non-conducting appliances; others without them, notwithstanding the clear and decided advantages to be gained by their use. Some makers use heat-diffusers; others say they are of no use. In others, so imperfect is their combustion that you have constantly a dirty deposit of carbon.

The manner in which stoves are supplied without suitable cooking utensils is another drawback. The cast-iron pots and kettles, well crusted from long service, are often used with gas-stoves with anything but good results, while bright tin or copper should be the rule.

It would extend this paper beyond its limits to give the statistics of several testings of the various makers. With equal pressures and quantities of gas I found varied results from the different apparatus. The conclusion arrived at is that there yet remains to be found a standard by which the best results may be secured.

In the application of gas as a motive power you have an illustration of this. It was looked upon as a very important step, and the first engine used for the purpose was certainly an elaborate machine. I refer to Lenoir's engine with the electric battery, &c. But you must have also heard that it was necessary to keep two or three cylinders in stock, so rapidly did they wear out. We next had Otto and Langen's, with considerably reduced wear and tear; but even this had its drawbacks. I remember to have seen at an exhibition a two-horse engine of this make, and near to this gas-engine, with the rattle of its gear and the unpleasant sound occasioned by its repeated explosions, was working a very compact steam-engine of the same power, but not half the size, and it worked without any noise. I can tell you that the impression made on the visitors was on that occasion decidedly in favour of the steam-engine. But now look at the result of well-directed skill, aided by correct principles. You have a gas-engine that can hold its own, perfect in details, noiseless in action, most compact in construction, and, as a well-merited reward of the attention thus bestowed on it, the makers and improvers are as busy as they can be in its extensive manufacture. I had recently an opportunity of visiting the works of Crossley Brothers, and I there saw in course of construction every size, from half-horse power to eight-horse, and they had orders on their books for 178 engines. We have seen what Crossley Brothers have done for the gas-engine, and Sugg for burners. We unquestionably require their imitators for stoves.

Another drawback to the use of gas-stoves is the manner in which they are often connected by gas-fitters. We all have had experience of the evils attendant on the work performed by incompetent fitters, and perhaps few things give more annoyance to gas managers than this, which I must call an evil. Consumers will have it that the fault is in the gas. It is of no use to point out that their neighbours are well supplied; and the gas-fitter often with a pretended knowledge will accord with the complainant, in order to screen his own cheap and unsuitable work. In this way you will find good gas-stoves in many instances rendered inefficient by the obtuseness of fitters. I have seen gas-stoves, requiring a supply of at least 15 feet per hour, connected with quarter-inch tubing. I have known instances where the place selected as most suitable by the gas-fitters was where the supply was most deficient, and, without taking the trouble to report or remedy the defect, they put it down to the inefficiency of the stove, and again I have also found where ignorance was so far displayed as to cover the apertures of the Bunsen burner where air is admitted. I need not tell you the result. As described by one gentleman who experienced it, it was so remarkable that you could hang your hat on the smell emitted.

Gas-stoves for heating are often fixed without any contrivance for taking off the products of combustion. When a stove of this kind is placed on the floor of an apartment, you have, to say the least of it, a disagreeable atmosphere. However nicely designed and ornamental a stove may be, without so necessary an appendage it is a mistake to use it. I know a gentleman who was anxious to enjoy the luxury of gas heating in a room

in which there was no flue, and he was unwilling to spoil the appearance of the apartment by introducing one; but he made a contrivance, which you will admit was very simple, and which I can tell you was very effectual. In the wall of the room over the doorway, at the height of 8 feet, he made a hole 6 inches square, communicating with the outer side of the room, and over this he hung a picture. The result is that he can now enjoy as much gaslight and heat as he requires without any inconvenience, and the appearance of the room is in no way interfered with.

Having indicated some of the obstacles by which gas for heating purposes is retarded, permit me to offer one or two suggestions with the view of assisting, to some extent, in removing the impediments; but if afterwards I learn that they have been supplanted by others, which in your experience you consider more conducive to the object in view, no one will be better pleased at the result than I shall be.

In the first place I must remark that, up to the present, gas companies, with a few exceptions, have not taken so active a part in this matter as they might. The reason, I should say, is owing to the fast increasing demand for gas for illuminating purposes. They found that to provide for this gave ample occupation for their time and capital; but inasmuch as there appears to be a more general desire recently to study the question, I submit that it is within the power of the companies to remove the difficulties by which its application is retarded.

In order to do so, the first step that appears to be necessary is recognizing the fact that gas-heating apparatus is to be perfected or improved. An inquiry should be instituted by a series of practical experiments into the principles on which heating gas can be applied with advantage.

In order to secure for this end the best scientific aid, a contribution from each of the well-to-do gas companies would soon form a respectable fund for this and all similar purposes; the Committee would thereby be able to secure the services of a thoroughly competent person or persons to prosecute the inquiry, and having ascertained the principles to be observed in the arrangement of the apparatus, there should be a premium offered to manufacturers for the best constructed apparatus in accordance with ascertained principles.

Gas companies would thereby place themselves in a position to afford correct information to their consumers.

Whatever difference of opinion may be entertained about extending their control to the point of combustion, so far as lighting gas is concerned, I certainly think that it should be within their province to see that consumers are supplied with proper apparatus, and that such are fixed in a proper manner.

In every large and medium-sized company it would tend very much to ensure success, if one of the officials made himself thoroughly acquainted with the construction of gas-stoves, and, in addition, an elementary knowledge of the first principles of cookery. They thereby would have at hand, at all times, a means of giving practical information on all points connected with the subject.

A disposition of this kind will be certain to create a mutual feeling of confidence between gas companies and consumers, and it will also be the means of introducing properly constructed apparatus, which will give such results as must lead to the extensive use of gas for heating purposes.

Mr. Gore said that having, 27 or 28 years ago, given the first public exhibition of gas cooking in London, he might be permitted to say a word or two on this subject. So much had been written and said on the application of gaseous fuel to domestic purposes, that in a meeting like the present it was scarcely necessary to repeat what had been so often reiterated. There was one point, however, which deserved their attention as manufacturers of gas—namely, whether it was possible, by the agency of gas, to utilize for heating purposes, in their own manufacture, some of the other products connected with gas. Some years ago he was connected with a patent for the purpose of using gaseous and liquid fuel in the manufacture of iron, and when it was at so high a price he undertook a

large number of experiments in connection with this patent. He then had to deal with a variety of contrivances for the purpose of improving the manufacture of iron. Mr. Cameron made a series of experiments, in which he endeavoured to produce the effect of puddling by the agency of coal in a finely-divided state. Others followed with experiments in which gas was employed for a similar purpose. It was true they could not compete with solid fuel; but they had taught some practical lessons—namely, that there were circumstances in which gaseous fuel could be advantageously applied. On one occasion he was visiting Chatham Dockyard, when the armour-plates for the *Sultan* had to be bent to different shapes to adapt them to the curve of the ship. It was found practically impossible to successfully heat them uniformly by an ordinary furnace.

Mr. GEORGE LIVESEY said he thought it would be well if Mr. Gore would confine himself to the subject on the paper which had been read.

Mr. GORE said the use of fuel in a gaseous form convinced him there were other modes, even beyond culinary purposes, to which gas manufacturers might direct their attention, the result of which, he believed, would be eminently advantageous to them. All Mr. Travers had said he fully endorsed.

Mr. GEORGE ANDERSON said the paper was one of the most practical which had been brought before the Society for a long time, but it did not require discussion so much as reflection. There was, no doubt, a great variety of apparatus, and he thought reflection and study would bring them all to the same conclusion Mr. Travers had arrived at—that it was necessary some arrangement should be made to winnow out the wheat from the chaff. One could go into any gas-fitter's shop and buy what was called a gas-trivet for two or three shillings, and a certain quantity of gas would be necessary to heat a kettle up to boiling point; but, if one simply placed a little cylinder which cost about 2d. over this trivet, one would decrease the quantity of gas and the time required by about 40 per cent., showing that in that small apparatus there was great room for improvement.

Mr. CARPENTER (Sheerness) said the consumption of gas in his district was not very great, and in order to increase it he recommended his Directors to introduce stoves and let them out. They had now something like 250 to 300. They had considerably increased the consumption, and found no great difficulty in giving a proper supply of gas at about 9-10ths pressure. Some stoves, however, required 11-10ths, some would cook at 6-10ths, whilst others required 15-10ths. He considered the great fault with gas-stoves generally was that the gasways were not made sufficiently large.

Mr. H. WOODALL (Leeds) said that, when using a gas-stove, he had noticed an unpleasant smell, and, looking under the stove, he found that one of the jets had been blown out, and it occurred to him that that was frequently the cause of this unpleasantness. Two or three weeks ago, in using Mr. Vernon Harcourt's colour tests, he observed almost identically the same smell proceeding from the gas heated after passing through the pumice. It occurred to him that the smell was that of gas which came into pretty close contact with the heat of the flame, by which it was not burnt, but broken up, and sulphuretted hydrogen liberated.

Mr. VERNON HARCOURT had no doubt that one of the unpleasant gases produced when any sample of coal gas was heated was sulphuretted hydrogen; but besides that there were no doubt other compounds of carbon and hydrogen which were also very offensive. He had noticed in his apparatus the same smell, and he always made a practice to burn these gases before they passed into the air of the room.

Major DRESSER (New York) said an instance had occurred in Providence, Rhode Island, which seemed exactly to the point. A gentleman went to his bath-room, in cold weather, to take a bath; lit the gas-stove, and turned it on full. It was calculated to burn about 12 to 13 feet per hour; but, as experiments afterwards showed, under the pressure he was using it, with the cock turned on full, it burnt 80 feet per hour. The young man not coming out of the bath, after an hour or two, his family went in and found him dead, and experiments showed that he was killed by carbonic oxide, the most deadly poison which arose from the use of

gas in any way. A long series of experiments were gone into by the parties interested in the stove and by the gas company. Pigeons and small animals were introduced into the room, and by using similar quantities of gas, burnt under similar conditions, they found the atmosphere of the room became so vitiated that pigeons would die in a very few minutes, and an analysis of the atmosphere showed that it was overcharged with carbonic oxide, the result of imperfect combustion of the gas. It was now universally acknowledged in America that the proper way to use a gas-stove was to have a chimney leading from the combustion chamber to the open air, so that the products of combustion might be carried off, and the makers of the best stoves always recommended their customers to use a chimney.

Mr. HUTCHINSON (Barnsley) spoke to the necessity of ventilation in rooms where gas was used for cooking purposes. It was most unreasonable to burn such large quantities of gas as were often used without making provision for ventilation. This arose from the very pure character of the gas generally supplied for that purpose, for if it was much more impure it would at once call for more attention.

Mr. CARR (Halifax) thought the production of carbonic oxide could only occur in a room with a very limited supply of oxygen, or a badly constructed stove, because, although it might be produced in one part of the flame, if there were an abundant supply of oxygen, the carbonic oxide would be consumed at the tip of the flame, before it escaped. He could scarcely think, therefore, that the smell so prevalent where gas-stoves were used could result from carbonic oxide being allowed to escape. He had noticed in several cases a very unpleasant smell; but it was generally that which was always found in very badly-ventilated public rooms —carbonic acid. He was not aware that carbonic oxide had any smell at all.

Mr. GEORGE LIVESEY had no doubt that carbonic oxide was one of the products of combustion, and he should be very glad if gas companies would undertake a series of experiments to investigate the products of combustion more thoroughly. Some had been undertaken, which went to show that the carbon in gas was not thoroughly consumed by any means. If it were all converted into carbonic acid, they could deal with it very well. There was no doubt, at present, the best means was to provide efficient ventilation. The main question of Mr. Travers's paper was as to the introduction of gas-cooking stoves by gas companies, and it seemed a right course for gas companies and corporations to let the stoves on hire, because individuals were not prepared to go to the cost of a stove, although they were quite willing to pay a reasonable rent for it. This would entail a certain amount of trouble on the officers of the companies or corporations, and that trouble, he thought, had been a great obstacle to the introduction of this system. They had felt that they had enough to do, and if they added to their labours, it would be regarded as a work of supererogation. In many cases the directors were not particularly willing to go into the question, and the manager had to press the subject, almost as a personal matter, to induce them to adopt it. So far had the existing principles on which gas companies worked acted detrimentally to their interest, that they had no inducement to push their business. He maintained that, under present circumstances, the best reply they could give to electric scares, or any other, would be to endeavour to push their business as any ordinary traders would do—to produce gas as cheaply as possible, and to get its consumption increased. He would say especially that the subject brought forward by Mr. Travers pointed to a direction in which that consumption might be materially increased, to the great benefit of the gas interest, enabling them to reduce the price and giving them a field of operation with which no electric candle could compete. He certainly should not be sorry to see the electric light come into use for many purposes, but it would never compete with gas for cooking. There would be a difficulty, no doubt, about the matter. It was difficult to select the best stove, but his own opinion was that where stoves were sold direct to the consumer, if he wanted a cheap stove he must put up with the consequence of it being soon worn out. But if they were to let stoves on hire, it would be a bad policy to adopt cheap

stoves. They wanted the best one, and it would be found to pay better to charge even something less than a full or fair per centage on the cost as rent for a thoroughly good stove, than a full per centage on the cost of a bad one, because the bad one would give no end of trouble, and the good one would cost less in the result. He was sorry that Mr. Gore concluded his interesting speech so soon, for he did not intend to cut him short by any means. He hoped something would be done to educate the public in the use of these things. As he was speaking, he would ask leave to refer to an expression he used yesterday, which might be misunderstood. His friend Mr. Mead made a statement about gas-works he was connected with having cost 16s. per 1000 feet, when he said he did not believe what was said. He was quite sure Mr. Mead understood it thoroughly, and he now found that Mr. Mead was right in what he stated, from his point of view. What he meant was, that the gas-works he had had to do with had capitals ranging from 16s. per 1000 feet and upwards, whereas his (Mr. Livesey's) statement had reference to the value of the plant which they possessed.

Mr. HELPS (Bath) said in his town they had a large consumption of gas for cooking and heating purposes. Some years ago they had a very energetic officer at the works, who constructed a very good cooking stove. This was used at the works, and they invited the Mayor and Corporation of the town to dinner, also the reporters and any gas-fitters who liked to attend. That was about ten years ago, and from that time the consumption for this purpose had rapidly increased. His Directors did what they could to increase the consumption of gas by introducing into their offices some of the best stoves made, both for cooking and heating. Many of the consumers came to the offices to pay their bills or make inquiries, and they then saw these stoves, and had them explained, whereas they would not take the trouble to go to a gas-fitter's or ironmonger's to see them. If directors would think a little more of these matters, and introduce stoves for show in a conspicuous part of their offices, it would bring about good results.

Mr. GILL (Bridgnorth) said he had been sending out circulars recommending gas for cooking in summer, and for heating apparatus in winter, and there were now in use about 150 stoves for boiling, and various cooking stoves, and about 25 for heating, which had much increased the consumption. The directors as well as the public were at first rather prejudiced, but now they saw the usefulness of doing so, and had fixed up a lot of stoves as suggested by the last speaker. With reference to the smell, there was a great deal in the manufacture of the stove, and it was wise to go to the best makers; at the same time, a good deal of the smell was occasioned by want of care. He had examined some stoves which were complained of, and found burnt grease all about them, and when this was removed there was no more complaint. In view of the possibility of less gas being used in future for lighting, it was of great importance that this subject should be borne in mind.

Mr. MEAD (Sutton) said he had had cooking done in his own house for 30 years by gas, and he had not been killed yet. With regard to its effect on gas companies, he found that in his own house it had just about doubled the consumption. When he was in London, his gas bills were the same in summer as in winter. He thought the two practical points to be insisted upon were, never to erect a gas-stove without having a chimney, and never to connect it with a small pipe.

Mr. MOORE (Macclesfield) said when he had to do with this matter some years ago, there was a large Institution, with between 800 and 900 inmates, whose coal arrangements broke down, and he induced the medical superintendent to allow him to try gas cooking for twelve months. They made the stoves, fixed them, and had a separate main and meter for the cooking arrangements. During the twelve months there was a great saving in cost, and 13 cwt. additional dripping was saved, which, at 4d. a pound, realized £30. Mr. Travers laid stress on the way in which stoves were fixed, and he had often found great neglect on that point. It was quite true, as Mr. Livesey said, that if this question were worked out successfully it entailed additional trouble on engineers. He gathered that Mr. Travers had given personal supervision to the matter, and he was satisfied that it

was only by engineers taking trouble themselves that an increase of consumption for cooking could be brought about. In the stoves, he had fixed ventilating-pipes out into the shafts, so that the draught was just that caused by the consumption inside, without any pull. Over the top of the boiler he fixed an iron ornamental awning fixed to the same flues, leaving a space round, and that took away all the steam and smell.

Mr. IRONS (Gosport) described a gas-stove designed by Alderman Copeland, which had been the means of prolonging life. The gas came through small apertures similar to those of the present atmospheric stoves; over these were metal thimbles, and over them porcelain balls. At the first aperture there was a small gas-flame; but as soon as the thimble-pieces were put over, the flame disappeared, and the whole of them got red hot. Then when the porcelain balls were put on the top of them, they got red hot, and the whole products of combustion were destroyed and carried away. This was used in the bed-room of a consumptive patient, and the physician stated that the stove had been the means of prolonging life.

Mr. HUNT (Birmingham) said the important point in selecting the best stove for hiring or selling was to find the one that consumed the least amount of gas for the heat produced.

Mr. TRAVERS, in reply, said since he had furnished his paper to the Association he had visited Birmingham, where there was a very gratifying exhibition of gas-stoves, many of which were calculated to remove some of the obstacles he had mentioned. With regard to the importance of gas companies taking the matter in their own hands, he might mention that in Cork they had introduced the hiring system, and found it very successful. Persons who would not think of laying out £1 for a stove, would readily take stoves which cost £5 on the hiring system. They had made arrangements that gas-fitters were not permitted to connect them, or, if they did, they must use certain sized pipes. They had also a Stove Inspector, whose duty it was to instruct consumers, and see that the stoves were properly at work, and that they were giving the best results. They had also a shop in the town, in which the stoves could be seen in operation, and in the window there was a constant exhibition of burners, good and bad, so that they could at any time refer consumers to this place, when they complained of the inferior quality of the gas or even of the stoves. He would conclude by saying that he trusted this subject would be now ventilated, and that the day was not far distant when the gas consumption would be almost the same in summer as in winter.

The PRESIDENT, in closing the discussion, said his only fear was that, when the happy time just alluded to arrived, he did not know when they would be able to hold their meetings.

PURIFICATION BY MEANS OF LIQUIDS, PRINCIPALLY CAUSTIC AMMONIA.

By Mr. F. D. Marshall (Brentford).

Many attempts have been made to effect the removal of H_2S, CO_2, and the so-called sulphur compounds by means of liquid reagents in closed vessels, and to dispense with the use of the objectionable lime or oxide of iron. As day by day the pressure is brought to bear, truly the unhappy gas companies are between the horns of a dilemma; for, in obedience to popular prejudice, while those wiseacres, the local authorities, insist on the removal of a few grains of sulphur, they, in the same breath, as much as forbid us the only practical means of accomplishing this end. Of champions in the cause, their name is legion—Wilson, in 1813; Phillips, 1843; Farmer, 1847; Mann, 1853; Laming, 1853, 1854, 1855; Leigh, 1866; Hills, 1870, 1874, 1875, 1877; Patterson, 1873; Paterson and Collinge, 1877; Evans and Sugg, Wallace and Claus, 1878, have all sought protection of the Patent Office for processes to effect the purification by liquids in some form or other, and we seem, in a measure, to be approaching the desired end.

Of the originality of some of the schemes it would be invidious to speak, for many seemed bent on treading in the footsteps of their predecessors, and original ideas cropped up at intervals, few and far between, although it is but fair to mention that a somewhat original path was carved out by Mr. G. Livesey, who purposed desulphurating the liquor by means of furnace gases, a detailed description of which appeared before you in 1875.

In the majority of the patented schemes, ammoniacal liquor plays the principal part, and this can scarcely be wondered at when we think of the peculiar advantages "liquor" presents for the purpose, possessing as it does a large supply of ammonia, which, in its free state, is capable of absorbing both CO_2 and H_2S quite as readily as lime itself; but, as the NH_3 is now obtained, it is bound up, so to speak, with CO_2 and H_2S, and to free it from these, in an economical manner, is the question we are all so earnestly endeavouring to solve. Many patents purposed treating ammoniacal liquor with caustic lime, and so converting the CO_2 into carbonate of lime, and setting free an equivalent quantity of ammonia, and another form purposed the decomposition of the liquor by heat, driving the gases thus set free through oxide of iron and lime. But these plans would present difficulties, for a large amount of aqueous vapour would pass over with the evolved gases, and be condensed in the lime, rendering it cloggy and non-porous; and to prevent this the lime would have to be kept hot and dry, to give free passage to the gaseous sulphide or caustic ammonia.

To test the feasibility of these plans, I was instructed by Mr. Woodall, while at the Phœnix Gas Company, to make some experiments, by adding caustic lime to gas liquor, and these showed the impracticability of accomplishing anything in this direction, for, besides losing a large quantity of ammonia, it was difficult to regulate the quantity of lime added to the liquor, in order only to precipitate the carbonic acid, for should the lime exceed a definite quantity the sulphuretted hydrogen would be absorbed with the carbonate as sulphide, and ultimately as bisulphide of calcium, and as such would be most voluminous and difficult of disposal. Should any one feel disposed to push inquiries in this direction, the following data, showing the quantity of lime required for a gallon of liquor of 8-ounce strength to precipitate the CO_2 alone, may be useful:—One bushel of lime requires 12 pounds of water to slake it, and 0·253 pound of

slaked lime are required to every gallon of liquor of 8-ounce strength to precipitate the CO_2.

This process was, however, partly anticipated by Livesey's patent in 1865.

Much publicity has been given to Hills's process, the details of which we are now familiar with. Suffice it to say, he aims at the production of caustic ammonia by heating the liquor to a temperature of 180°, whereby the CO_2 and H_2S are separated from the NH_3, the two former passing away, while the latter is re-absorbed by fresh liquor, and carried back to the boiler. Of the effectiveness of this scheme I speak guardedly; for while, on the one hand, I am assured by Mr. George Livesey that he has worked it successfully, and intends purifying nearly the whole of his gas from CO_2 and H_2S by this means, yet I am in a position to quote analyses of liquors obtained from the outlet of boilers where this process was under trial, and these reveal the fact that the action was not complete, and that the NH_3, in all the samples taken, existed nearly wholly in the combined state—that is, as carbonate and sulphide of ammonium—and the free ammonia in no case exceeded more than 0·144 per cent. As the actions spoken of only take place within the limits of certain temperatures, considerable difficulty was experienced in maintaining the boilers at an equable temperature.

Another process for the removal of the H_2S was that of Marriott, of Huddersfield, and extensive trials were made of the process at the Vauxhall station of the Phœnix Gas Company about a year ago. It principally consists in breaking up the H_2S in crude gas by means of sulphurous acid ($SO_2 + 2H_2S = 2H_2O + 3S$), whereby the oxygen in the SO_2 combines with the H of the H_2S, forming water, and the equivalents of sulphur from the SO_2 and the H_2S are eventually recovered, to be used over again in the manufacture of sulphurous acid gas. To effect this the sulphurous acid is brought into contact with gas liquor, converting it first into a sulphite, and then into a bisulphite of ammonia, and in this condition it is used for scrubbing the gas. So far as the removal of the H_2S was concerned, the plan was perfectly successful; but the chief drawback was due to the destructive influence of a certain amount of free SO_2 on the iron employed in the construction of the pumps and apparatus; but there is no doubt this may be remedied by the employment of lead, stone, or gutta percha in the construction of the apparatus. Neither the CO_2 nor sulphur compounds were acted upon by the bisulphite of ammonia; but, on Mr. Marriott's authority, by treating the bisulphite of ammonia with an excess of SO_2, it can be converted into a pentathianide of ammonia, and in this condition the inventor states he has removed bisulphide of carbon compounds.

But practically we were never able to impregnate the liquor with more sulphur than to form a bisulphite. The whole process can scarcely be called original, for in 1831 Lowe and Croll, 1856 Gossage, 1862 Livesey, and 1869 Bauher and Dale, took out patents all more or less covering the same ground, the only difference being that some employed free SO_2, while others used ammonia as the carrier of the SO_2.

It seems admitted, beyond doubt, that both CO_2 and H_2S may be efficiently removed by caustic ammonia, or purified gas liquor, but how far the sulphur compounds are affected by sulphide of ammonium or purified gas liquor we have not extensively published data. That they are affected by sulphide of ammonium, and by soluble and insoluble sulphides, we are prepared to admit. I have had occasion to make experiments in this direction, and began with crude gas liquor, of 9-oz. strength, with 1-20th part of alcohol added. This was passed through scrubbers filled with pumice stone, with this effect—Sulphur at inlet of scrubbers 23 grains, and at outlet 12 grains; the difference being 11 grains. Several series of experiments bore out these results.

The experiment was repeated without alcohol; the sulphur, however, at the inlet was 33 grains, and at the outlet 22 grains; difference, 11 grains. An abnormally strong liquor was then obtained—viz., 29-oz. strength, and used in a similar manner, but without any alcohol. The results were—Inlet of scrubbers, 30 grains; outlet, 16·5 grains; difference, 13·5 grains. Unfortunately, a correct measurement of the liquor was impracticable, so large

was the amount carried away by the passage of the gas, but as long as it lasted it seemed capable of doing good work.

These experiments were made on gas free from H_2S, but containing 0·8 per cent. of CO_2. During the experiments frequent trials were made to ascertain any diminution of condensable hydrocarbons or carbonic acid, and we found—

Inlet of scrubbers:

Condensable hydrocarbons	4·0 per cent.
CO_2.	·8 „

Outlet of scrubbers:

Condensable hydrocarbons	4·0 „
CO_2	·6 „

showing no diminution of hydrocarbons, but a reduction of 0·2 per cent. of CO_2. These experiments were repeated with sulphide of ammonium, and the average result of a series of trials showed a reduction from 27 grains to 17 grains of sulphur—difference, 10 grains. With caustic ammonia the results were very variable; but a reduction of 10 grains of sulphur could easily be obtained. To my mind, it seems that, with more efficient scrubbing power, and longer contact of the gas with the reagent, much greater diminutions might be effected, and this has been borne out by a further series of experiments, also under the direction of Mr. Woodall, with another soluble sulphide—viz., sulphide of barium—patented by Messrs. Wallace and Claus. This baric sulphide is prepared from sulphate of baryta, found in large quantities in Derbyshire and all lead-bearing districts, and known locally by the name of "cowk."

After being crushed with an equivalent of powdered coal, and heated in a reducing furnace, the sulphide of barium thus formed is dissolved out, and is ready for use. For the experiments, which extended over some months, two towers, 24 inches in diameter, and 9 feet high, were used, fitted with a "tumbling-box" distributor, and the average of the observations showed that 40 gallons of saturated barium sulphide purified 9000 cubic feet of gas, reducing the sulphur from 26 grains at inlet to 6·3 grains at outlet, making a difference of 19·7 grains.

The average quantity of gas per hour was 1200 cubic feet. Had the towers been of larger capacity, and the scrubbing area increased, the work done by the barium would have been probably much greater.

Experiments made by Mr. Frank Morris, the Engineer at Brentford, showed like good results. There is, however, one great difficulty to contend with, when dealing with barium, and that is its great tendency to become both carbonated and oxidized by the action of the atmosphere, and great precautions must be taken to keep it covered up and free from exposure. Mr. Marriott is now, I believe, experimenting at the Fulham Gas-Works with another sulphide—viz., sulphide of sodium—and we shall, no doubt, shortly hear with what results.

And now we come to review these systems of purification for the production of caustic NH_3, we find ourselves at the unprofitable and scarcely amusing occupation of carrying the parson round the church, for we are reduced to the clumsy and wasteful process of treating liquor with lime, or *vice versâ*, by which we create a bulky waste product of carbonate of lime, and the CO_2 and H_2S, which ought to play their parts in the purification, are entirely lost or rendered useless, and the whole thing is nothing but lime purification by proxy. And presuming we have economically manufactured the caustic NH_3, we are by no means certain of the best way of introducing it to the gas, so as to avoid an excessive and unprofitable washing power for removing the NH_3, that the gas must necessarily assimilate during its passage; and in the case of purification by sulphides, we must, for cogent reasons, remove first the CO_2, and perforce use the familiar oxide to remove the H_2S carried forward by the gas, while in the case of sulphide of ammonium, both washing and oxide must be had recourse to.

I mentioned that we must first rid the gas of CO_2 before entering a sulphide purifier or vessel; for those of us who are unfortunately compelled to use lime purification are fully alive to the influence of CO_2 on

sulphide purifiers—viz., the expulsion of the H_2S—and this equally applies to liquid reagents, as the following experiments made at Vauxhall satisfactorily show:—

Four small scrubbers were employed, and sulphide of ammonium was put into the first two scrubbers, and caustic ammonia into the second two. Assuming the crude gas to contain 4 per cent. of CO_2, the theoretical quantity of gas required to be passed, to convert the sulphide of ammonium into the monocarbonate, would be 39 cubic feet, or into the bicarbonate, 78 cubic feet. The composition of the sulphide of ammonium in scrubbers Nos. 1 and 2 was—

Ammonia	4·90 per cent.
Sulphuretted hydrogen	3·25 „

After passing 20 cubic feet of crude gas at the rate of 6 feet per hour—

No. 1 scrubber contained	1·48 per cent. of H_2S.	
4 „ „	1·56 „	„

After, however, 83 feet had passed—

No. 1 scrubber contained	·60 „	„
2 „ „	·72 „	„
3 „ „	·58 „	„
4 „ „	·58 „	„

After passage of 140 cubic feet—

No. 1 scrubber contained	·66 „	„
2 „ „	·65 „	„
3 „ „	·68 „	„
4 „ „	·58 „	„
No. 1 scrubber also contained	6·89 „	NH_3.
„ „ „	9·66 „	CO_2.
„ „ „	·66 „	H_2S.
No. 3 scrubber also contained	5·50 „	CO_2.
„ „ „	·68 „	H_2S.

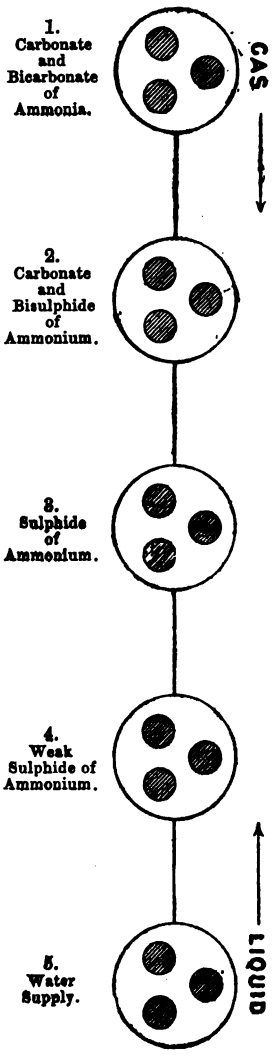
Thus it will be seen that in the first scrubber (originally containing sulphide of ammonium) we get an increase of ammonia from 4·9 per cent. to 6·89 per cent. We also find 9·66 per cent. of CO_2. To convert the 6·89 per cent. of NH_3 into monocarbonate of ammonia, it would require 8·9 per cent. of CO_2, or a proportion of 22 of CO_2 to 17 of NH_3; instead of which we have 9·66 per cent. of CO_2, or a proportion of 24 of CO_2 to 17 of NH_3; clearly proving the formation of a bicarbonate of ammonia, and a thorough expulsion of the H_2S; for as H_2S cannot exist along with sesqui or bicarbonate of ammonia except in the free state, the 0·66 per cent. of H_2S remaining must have assumed the free state, and have been held mechanically in solution—that is, about 15 per cent. of the original 3·25 per cent. of H_2S remained in the free state after all the ammonia had been converted into more than monocarbonate of ammonia. The experiments were carefully conducted, and the CO_2 and H_2S in the liquors determined by volumetric analysis.

This clearly points to the fact that CO_2 is absorbed by sulphide of ammonium with expulsion of H_2S, and that a mono or bicarbonate of ammonia is formed; but how far the absorption of CO_2 takes place in ordinary scrubbers may be gathered from the carefully conducted and beautifully recorded experiments made by Mr. M'Minn at the Fulham station of The Gaslight and Coke Company. The average of a number of trials, extending over a long period of time, showed, at the inlet of scrubbers, 2·002 per cent. by volume of CO_2, and at outlet, 1·764 per cent.—reduction, 0·238 per cent.; while experiments quoted a short time back, when on the subject of scrubbing with ordinary liquor, showed a reduction from 0·8 per cent. to 0·6 per cent.—difference, 0·2 per cent.; and further experiments made on a screw condenser, at the Vauxhall station of the Phœnix Company, proved a diminution of from 1·2 per cent. by volume at the inlet to 0·32 per cent. at the outlet, the difference being 0·88 per cent.

It is on this theory of the power of gas liquor to absorb CO_2, and, at the same time, to displace H_2S, that induced Messrs. Wallace and Claus to

take out their patent for the production of caustic ammonia, and the special feature of their process is the employment of a series of peculiarly constructed scrubbers or towers, whereby this "fractionation," or splitting up of the constituents of the liquor, takes place. The construction of the towers may be described thus—

They are square in form, of a capacity proportioned to the make of gas, the distributing arrangement consisting of a "tumbling box," or angular receptacle, one side of which, being presented to the incoming liquor, is overbalanced, the contents spilled over the receiving surface of the scrubber, and by the same movement the other side is in its turn presented to the liquor, filled, and eventually toppled over.



Caustic Ammonia pumped back into No. 3 Tower.

The interior of the scrubber itself is fitted with layers of angle-iron, made with rather an acute angle, and these angle-irons are laid each layer transversely across the other. This has the effect of splitting up the liquor into an extremely fine rain, capillary attraction being overcome by the transverse arrangement of the angles. A glass door let into the side of one, by the patentee, revealed the rain-like drops when the apparatus was at work.

In these towers, the "fractionation" of the liquor takes place by the action of the incoming gas, the H_2S being expelled to be absorbed by subsequent towers. For the sake of illustration, we will assume five groups of towers are erected, consisting of three to each group. The reason the group arrangement is preferred is, in case the reaction is not complete in the first tower of the group, the second or third tower of the group will complete the action, and thus the liquors be kept separated.

The gas passes through the sieves from 1 to 5, while the supply of the necessary water is pumped to meet the gas in the contrary direction, from 5 to 1, so that by the time it arrives at group No. 1 it is converted into moderately strong liquor, or a mixture of sulphide and carbonate of ammonia. This liquor is pumped for some time up and down group No. 1, so that, by contact with the CO_2 contained in the crude incoming gas, its H_2S is displaced, and pushed forward to group No. 2, where it is met by the liquor pumped backward from group No. 5, and re-absorbed as sulphide of ammonium. On the contents of group No. 1 assuming the desired form of carbonate, or preferably bicarbonate of ammonia, they are withdrawn and subjected to heat in a suitable vessel, at a temperature of 180° Fahr., and the ammonic carbonate is driven off in a vaporous form, and condensed in a concentrated state in another vessel. The residual liquor, after the carbonate of ammonia is driven off, is principally water containing a small quantity of carbonate and sulphocyanide of ammonium, and this may be re-introduced into the last series of scrubbers.

The concentrated ammonic carbonate is then mixed in another suitable vessel with an equivalent of common salt—chloride of sodium (Na Cl), $NH_4 CO_3 + Na Cl = NH_4Cl + Na O_3 CO_2$. Chloride of ammonium and carbonate of soda are formed. This carbonate of soda, being soluble, would be difficult to obtain as such; but recourse is had to its conversion into a bicarbonate by the addition of an equivalent of CO_2 pumped into it, and bicarbonate, being insoluble, is immediately thrown down. This CO_2, in the first instance, is obtained from an extraneous source; but the bicarbonate of soda once formed, is eventually heated, and the equivalent of CO_2 given off is again stored for future use. The bicarbonate of soda is separated from the chloride of ammonium by a centrifugal pump, or by filtration. The ammonic chloride is then heated in a boiler with slaked lime, with the formation of ammoniacal gas, chloride of calcium, and water.

$$NH_4 Cl + Ca O HO = NH_3 + Ca Cl + 2 H_2O$$

The calcium chloride, representing the whole of the lime used, is withdrawn in the soluble form, and may be used for sanitary purposes as a disinfectant.

The ammonia gas is absorbed by water as liquor ammonia, or is pumped back in the gaseous form into group No. 8 to effect primarily the removal of the H_2S pushed forward from the preceding groups, and, secondarily, the removal of the sulphur compounds; while a plentiful supply of water entering the last of the series will wash out any free NH_3 carried forward by the passage of the gas.

Such is an outline of the process for the manufacture of caustic ammonia it has been my endeavour to make intelligible in a few words; and when we think of the efforts that have been made to produce caustic ammonia, we are impressed with the importance of any process which bids fair to remove the difficulties that have hitherto been in the way of success, and for the production of bye-products, which are themselves of great practical utility and a source of wealth.

Of the chemical part of the operation there can be no doubt, for it is simply an adaptation of the ammonia-soda process now in active work on the Continent, although comparatively little known in England, whereby no less than 1000 tons of carbonate of soda are produced weekly, one firm alone making 400 tons per week, and this firm is enabled to send its products to the very doors of the most favourably situated alkali makers in Germany, and there undersell them in spite of a heavy import duty. It is, however, to the "fractionating" process in the scrubbers that we must turn our immediate attention, and being granted the fact that CO_2 is continually pushing forward the H_2S, I think this may be comprehended if we imagine an ordinary tall scrubber cut into three portions and placed side by side. In the first section, representing the bottom or inlet of the scrubber, we should probably find the liquor principally carbonate or bicarbonate of ammonia; in the second portion, representing the middle of the scrubber, the liquor would be a mixture of sulphide and carbonate; while, in the third portion, representing the top of the scrubber, the liquor would be nearly all sulphide, and thus the liquors from each portion be kept separated. Whereas, were the portions of the scrubber all on end, making one vessel, the liquors in the various states of transition would be mixed in a receiving-tank common to all.

And now let us see what we gain by a system of purification based on this plan. First, and all-important, no foul lime; and the lime used for the production of the NH_3 would be 20 per cent. less than that required for the removal of the CO_2.

All operations being carried on in permanently closed vessels, nuisance is reduced to a minimum. Pumping to a large extent will supersede manual labour. No solid refuse to barge away, but a soluble residue of calcic chloride, useful as a deodorizer.

The CO_2 hitherto wasted is utilized for the production of carbonate of soda, at a large profit.

The H_2S is absorbed as sulphide of ammonia, thus yielding sufficient material for sulphate manufacture.

The apparatus consisting principally of scrubbers, there would be great

economy of space; and last, but not least, the probable solution of the sulphur question.

It will be urged that by adopting this system gas-works will be converted into huge chemical works, but this need not necessarily be, for the bicarbonate of ammonia solution could easily be barged to neighbouring works, and the liquid caustic ammonia sent back to the gas companies.

I may mention that the ammonia-soda process was patented by Dr. Gerlach, of Kalk, near Cologne, and the process may be seen at work at a factory near Brussels.

The accompanying figures, handed me by the patentees, Messrs. Wallace and Claus, will convey some idea of the enormous profits arising from the manufacture of the carbonate of soda.

Assuming the CO_2 to be 2·4 per cent. by volume of the gas as it leaves the scrubbers, and CO_2 being three times heavier than coal gas, then the per centage by weight will equal 7·2 per cent.

Coal gas gives one-fourth of its weight of gas, so, taking a weight of 300,000 tons of coal, will produce 75,000 tons of gas, therefore the weight of CO_2 in 75,000 tons of gas will be about 5037 tons.

Add the CO_2 in the ammoniacal liquor, found thus: The quantity of sulphate of ammonia produced from 300,000 tons of coal will be 3272 tons, the actual ammonia in which is one-fourth, or 818 tons. Three-fourths of this is in combination with CO_2 gas, representing 613 tons. Every 17 tons of ammonia will hold 22 tons of CO_2 gas in combination; 613 tons will, therefore, combine with 793 tons of CO_2 gas; and the total CO_2 in the gas will be 5037 + 793 = 5830 tons.

To produce 54 tons of carbonate of soda will require 22 tons of carbonic acid, so that the 5830 tons of CO_2 would produce 14,310 tons of carbonate, worth £10 per ton = £143,100.

The cost of manufacturing a ton of soda would be—

Fuel	1	0	0
Labour	1	0	0
Salt	0	15	0
Wear and tear	0	2	0
Total	£2	17	0 × 14,310 tons

= £42,215 deducted from £143,100 would yield a profit of £100,885.

In conclusion, I thank you for your indulgence to so long a paper; but I plead the importance and advantages of a process by which we may not only reap great benefits ourselves, but earn the gratitude of the capricious public, and even be in the enviable position to offer a sop to the sanitary Cerberus, who will henceforth be able to flush his sewers and water his streets with tons of deodorizing matter, and render our towns as healthy as the famed "Hygeia" itself.

On the suggestion of the President, it was agreed that the discussion on Mr. Marshall's paper should be postponed until after the reading of one by Mr. F. Livesey.

SOME EXPERIMENTS WITH AMMONIACAL LIQUOR AS A PURIFYING AGENT.

By Mr. F. Livesey (London).

In working out the experiments of which this paper is a description, I have felt that the subject is not in sufficiently competent hands to give the question the thorough investigation it deserves. It should properly be dealt with by a gas-maker who is also a clever chemist. I hope, however, the experiments I shall bring before you may be of use, and that, perhaps, they may lead to some useful results.

It has often been expressed that the purification of gas will ultimately be accomplished in closed vessels, by means of the ammonia produced in the carbonization of the coal, and many attempts have been made in this direction without much success.

There is, however, this satisfaction, that all attempts made bring some further knowledge to bear on the subject, and so help on this much-to-be-desired object. One chief obstacle in the way to this end is that the quantity of ammonia produced is only sufficient to purify about one-sixth part of the gas, so it seems necessary to use the ammoniacal liquor some six times over, being subjected to a purifying process after each succesive operation.

Lime, if used in a proper manner, will purify gas from sulphuretted hydrogen (H_2S), carbonic acid (CO_2), and the greater portion of the sulphur compounds, and as there are many points in common in the chemical affinities of lime and ammonia, it is only to be expected that ammonia would do similar work to lime.

To remove the sulphur compounds, lime must be in the form of sulphide, and the gas must be free from CO_2. These conditions were formerly considered sufficient; it is now, however, certain that H_2S in any appreciable quantity interferes materially with the power of the sulphide of calcium to absorb the sulphur compounds.

Now, there is little difficulty in taking out the H_2S and CO_2 by means of the ammonia present, if in sufficient quantities; but to take out the CS_2 becomes the difficulty, for a foul liquor must be applied to a comparatively clean gas, thus making the gas once more foul by taking up H_2S and NH_3 from the liquor, and so rendering purifiers and scrubbers again necessary.

Lime, when carbonated, is of no use for taking out the sulphur compounds, and it is the same with foul ammoniacal liquor, which is generally half carbonated when applied. A sulphide of ammonium is a difficult liquor to produce in ordinary gas-making, and, when made, difficult to apply, for the reason I have mentioned before, and also because it so readily gives up its ammonia to a clean gas. Where one impurity can be driven forward from foul lime—viz. (H_2S), by CO_2; from foul liquor the gas will carry forward three—H_2S, CO_2, and NH_3.

These reasons seem to me the cause why ammonia has not yet effected the entire purification of gas.

That ammonia will, and does, accomplish much in the purification is well known, and these experiments have been made with a view to get the greatest amount of good out of it.

If sulphide of calcium is exposed to the action of gas containing CO_2, it will ultimately become more carbonated as the contact is continued, and with ammoniacal liquor it is much the same, thus leading to the conclusion that by long contact with the gas, a greater proportion of CO_2 will be removed, while with a short contact and a weak liquor HS_2 will chiefly be taken out. Taking into consideration that the gas liquor is used in the

earliest stages of purification, it is unquestionably better to get rid of the CO_2 by its means than by lime, and it seems better to work the liquor with that object in view. No plan, I believe, of working gas liquor will take out the CO_2 so effectively as a purified liquor, or certainly not in sufficient quantities to do away with the necessity for CO_2 boxes.

It will be found that every ounce strength of ammonia in gas liquor equals 0·347 oz. of absolute ammonia, which will combine with 416 cubic inches of H_2S to form sulphide of ammonium, $(NH_4)_2S$, or with 414 cubic inches of CO_2 to form carbonate of ammonium, $(NH_4)_2CO_3$; so that every ounce strength of NH_3 in the liquor should show, if entirely combined, some 416 cubic inches of impurities.

TABLE No. 1.

Description of Liquor.	Cubic Inches of Impurities per Gallon.			Cubic In. of Impurities per Ounce of Strength.	Ounces of (distilled) NH_3.	Ounces of NH_3 Acid Test.
	H_2S.	CO_2.	Total.			
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
1. From Livesey's scrubber washer, supplied with water	4339	1972	6311	394	—	16
2. Ditto, ditto.	3967	595	4562	456	—	10
3. Livesey's washer liquor	2200	7158	9858	426	—	23
4. Ditto ditto	1983	9982	11965	443	—	27
5. Ditto ditto	1952	1176	3128	368	8½	8½
6. Ditto ditto	2200	1313	3513	379	9½	8
7. Mann and Walker's scrubber (small size)	1611	8606	10217	537	—	19
8. Ditto ditto (large size)	1301	13984	15285	436	—	35
9. Ditto ditto, ditto	1890	5574	7464	439	—	17
10. Condenser	1115	1233	2348	313	7½	6½
11. Ditto	1363	1159	2522	325	7¾	6¾
12. Hydraulic main	464	308	772	154	5	3
13. Ditto	433	457	890	162	5½	3
14. Purified liquor	434	247	681	113	—	6
15. Liquor before purification	2076	3088	5164	368	14	—
16. Same liquor after purification	620	1233	1853	132	14	—
17. Liquor before purification	2076	2002	4078	370	11	10
18. Same liquor after purification	867	489	1356	123	11	10
19. Experiment to saturate a 9½ oz. liquor, foul gas passing into it, ammonia kept back by acid	867	2907	3774	397	9½	—
20. Experiment to saturate a pure ammonia solution with H_2S	3533	—	3533	430	8 1-5th	8 1-5th

Table No. 1 gives an analysis of gas liquors from the different condensing and purifying apparatus. Column No. 1 shows the number of cubic inches of H_2S per gallon; No. 2, the number of cubic inches of CO_2; No. 3, the total number of cubic inches of impurities; No. 4, the total number of cubic inches of impurities per ounce of strength; No. 5, the strength of ammonia.

Take the hydraulic main liquor (No. 12). This contains only 154 cubic inches of impurities per ounce, instead of 416; another analysis (No. 13) of hydraulic main liquor, 162. Condenser liquor contains more, but still much short of the standard. Two different samples (Nos. 10 and 11) give 313 and 325, whereas an analysis of washer liquor (No. 6) in one case gives 379.

It will be noticed that several are over the standard of 416—the one from a Mann and Walker's scrubber (No. 7) showing as much as 537; but this may be caused by there being no distillation test for this sample. I have little doubt, had such been the case, the figures would have been much reduced. Where the liquor has been distilled for

the ammonia strength, the result is taken as the divisor; and it will be noticed that, under these circumstances, they never reach higher than 379 (Nos. 6 and 16).

Hills's purified liquor (No. 18) is about as pure as the hydraulic main liquor, containing only 182 cubic inches of impurities per ounce. Another analysis (No. 18) gives only 128 per ounce, the same liquor having contained before 370. The hydraulic main liquor is always weak in impurities, from, I suppose, the same reason that enables Mr. Hills to purify gas liquor—namely, by heating it to something below boiling point, and so driving off the H_2S and CO_2. The temperature of the liquor in the hydraulic must be sufficient to prevent the combination of these impurities, and so leave them to be carried on with the gas till the temperature is reduced.

TABLE No. 2.

Ammoniacal Liquor, How Used.	Cubic Inches of Impurities removed per 1000 Cubic Feet of Gas.			Cubic Inches of Impurities removed per 1000 Cubic Feet of Gas per Ounce of Increased Strength.	Gallons of Liquor used per 1000 Cub. Feet of Gas.	Increase in Ammonia Strength.	
	H_2S.	CO_2.	Total.			Acid Test. Ounces.	Distilled. Ounces.
	No. 1	No. 2	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
1. Livesey's large washer, foul gas entering	720	994	1714	487	1·01	3½ viz., 7 -10½	—
2. Ditto ditto	5688	3574	9262	1684	4·37	5½ ,, 7½-13	—
3. Ditto ditto	8675	2122	10797	5398	8·4	2 ,, 6 - 8	1½
4. Livesey's foul gas entering, water used	1747	1429	3176	317	·75	10 ,, 0 -10	—
5. Livesey's large washer; liquor left in washer 42 hours, foul gas entering	347	2723	3070	175	·45	17½ ,, 7½-25	16½
6. Livesey's scrubber washer, entering as water	2892	1315	4207	262	·66	16 ,, 0 -16	—
7. Mann and Walker's scrubber, entering as water	1007	5379	6386	336	·62	19 ,, 0 -19	23½
8. Ditto ditto	1039	3067	4106	241	·55	17 ,, 0 -17	—
9. Livesey's washer, entering as Hills's purified liquor, gas having previously passed one washer	1139	1414	2553	2553	·69	1 ,, 12 -13	—
10. Ditto ditto	745	1426	2171	931	·71	2½ ,, 13 -15½	3
11. Ditto ditto	1999	3804	5803	4363	1·56	1½ ,, 10 -11½	2
12. Ditto ditto	1236	1466	2702	2702	1·4	1 ,, 5 - 6	½ (6—6½)
13. Hills's purified liquor, foul gas entering	5097	2228	7325	3662	2·9	2 ,, 6 - 8	—
14. Ditto ditto	4099	2683	6782	1937	2·1	3½ ,, 5 - 8½	3½ (6—9½)
15. Anderson's washer, conditions not known	1858	1378	3236	588	1·33	5½ ,, 0 - 5½	—
16. Scrubber liquor entering as water, gas not foul.	505	409	914	294	·52	3⅔ ,, 0 - 3⅔	—

N.B.—By foul gas is meant gas coming from condenser.

Table No. 2 is for the purpose of showing the work done by the liquor in passing through either washer or scrubber, as the case may be. The first column shows cubic inches of H_2S removed per 1000 cubic feet of gas; the second column, the amount of CO_2; and the third column, the two combined. The fourth column, which shows the work done, gives the cubic inches of impurities removed per 1000 feet of gas for every ounce of strength the liquor increases in passing through the vessel. The next column shows the quantity of liquor used per 1000 feet of gas, and the last two columns show the ammonia strength.

In estimating the amount of work done by any liquor, the state of the gas must be taken into account; for, if the gas is comparatively clean, the liquor will not do so much work. It will be noticed that the best results, in regard to removing the greatest quantity of impurities, are gained by the use of an excessive quantity of liquor. In experiment No. 3 in the table, as much as 10,797 cubic inches of impurities were removed per 1000 feet of gas; but, to obtain this effect, 8·4 gallons of liquor were used for the same quantity of gas, being about three times the total quantity of liquor produced from that gas. I, however, judge from this and other experiments, that, by the use of a large quantity of liquor, H_2S will be most easily removed; a longer contact being required for the combination of CO_2.

Experiment No. 5 shows this: A washer was filled with liquor, being equal to about half a gallon to every 1000 feet of gas passed through. The same liquor was left in the washer 24 hours. The liquor in this case removed more CO_2 than in the previously mentioned experiment. The gas being, in both cases, in the same state of foulness. If, therefore, you could leave gas liquor in a washer without increasing its strength, it would ultimately become carbonated to somewhat the same extent as a lime purifier.

The hydraulic main liquor contains, as other analyses have shown, the largest proportion of fixed salt; the condenser liquor, the next largest proportion; and the scrubber and washer liquor, least. Here are a few examples:—

	Acid Test. Oz.	Distilled.	Twaddel Doubled.
Hydraulic main liquor	8 ..	5½ ..	4½
Condenser „	6½ ..	7½ ..	3½
Do. „	6½ ..	7¼ ..	4¼
Mann and Walker's scrubber . .	19 ..	23½ ..	21
Livesey's scrubber-washer liquor.	11 ..	13½ ..	2½
Ditto „ „ . .	13 ..	— ..	6
Hills's purified liquor	5 ..	6 ..	0
Do. „	6 ..	— ..	1
Do. „	10 ..	11 ..	2¾

The last column shows most conclusively that Twaddel's hydrometer is of no use for indicating the strength, and more especially will the discrepancy be noticed with purified liquor, the first on the list of that class showing a 6-oz. liquor to have no strength, this particular liquor containing little or no CO_2.

My conclusions as to the best way of working gas liquor are as follows:—Should it be required to make the best use of the liquor, in the ordinary way of working, one point certainly to be remembered is to pass the condenser liquor through some efficient washer or scrubber, as this liquor has not generally above two-thirds its proper quantity of impurities. Analyze the liquor, to see if it contains its proper complement for its strength, and if it does, there is little use in working it over and over again, unless it is convenient to concentrate it for purposes of carriage.

To use the liquor for the removal chiefly of CO_2 seems to be rather a difficulty, for by keeping it in long contact with the gas, though more CO_2 is removed, less purifying work is done.

The best purifying results, however, both as to H_2S and CO_2, are obtained by bringing the gas produced from a certain quantity of coals into contact with from three to six times the quantity of liquor produced from the same quantity of coals, and at the same time subjecting the liquor to a continuous purifying process; or, in other words, the great thing desired is more ammonia. This, of course, means a large liquor purifying power, which is, however, in most cases, easy of adoption. Whether the purification of the gas will be improved by concentrating or distilling the ammonia is still an open question, for, when strong ammonia is used, that impurity is so readily carried forward. To use gas liquor for the removal of the sulphur compounds seems to be a very difficult matter, for these reasons—The gas must be comparatively pure from CO_2, H_2S, and NH_3; the first two gases because the ammonia will not react upon the sulphur

compounds in their presence, and the latter must be removed in taking out the two former. So that here is the gas, once purified, to be made quite foul again, and so render necessary a duplication of all purifying apparatus.

The mere record of experiments in the form of tables is not an interesting subject to read a paper about, and I must, therefore, ask for your indulgence if it has proved somewhat tedious. If this has been the case, it is not the fault of the subject, which is both useful and interesting, but of the writer, who is anxious to have his conclusions sifted by your criticisms.

Mr. HUNT said the members were much indebted to Mr. Marshall and Mr. Livesey for their papers. The subject of liquid purification was one of immense interest to gas manufacturers, and any information given with regard to it ought to be well discussed. With reference to Mr. Marshall's paper and the Hills decarbonating process, as practised by Mr. Livesey, he hardly understood the conclusions at which he had arrived. He stated that the liquor, after having been treated as Mr. Livesey did, contained very little free ammonia, and that was hardly consistent with the fact that the ammonia so treated took up a certain amount of sulphuretted hydrogen, and also that there was such a proportion of sulphuretted hydrogen and carbonic acid liberated. So far as he had been able to study the subject, Mr. Hills's process offered, for the present, the most practical solution of the question. With reference to the process patented by Messrs. Wallace and Claus, the figures Mr. Marshall had presented were certainly very tempting, and ought to induce them to give great attention to it; but in order to arrive at those satisfactory results, the ammonia sulphur process being such a success as had been stated, they were asked to introduce into gas-works an entirely new chemical process, which required really separate treatment and separate management. The difficulty was not with regard to the treatment of the carbonic acid and the sulphuretted hydrogen, it was to obtain the source of fresh ammonia. There was nothing really new in Messrs. Wallace and Claus's process with regard to the scrubbing, but simply with regard to the supply of ammonia, and there was the difficulty. If they could show that their process was practicably workable and profitable, he had no doubt it would be speedily adopted.

Mr. GORE said Mr. Hunt had touched on an important question in connection with the application of liquids to purify gas, and had asked a question which he could answer—namely, how were they to provide the ammonia in the form in which it should become applicable to purifying purposes? It was the misfortune of managers, abroad especially, to have great difficulty in getting rid of their residuals, and ammonia water was one of the greatest bugbears a manager abroad could have to contend with. Now, in dealing with the products some years ago in Valparaiso, his attention was drawn to the use of ammonia for purifying purposes, and to a way in which it could be readily applied. He had a process by which it could be converted directly from the gas liquor into caustic ammonia, and he found it eventually so profitable that he gave up its use as a purifying agent, and sold it to the silver reducing companies for the purpose of reducing silver from ores. He contended that the production of these compounds from the residuals was to all intents and purposes a branch of a gas manager's duty. It was simply following out the principles he ought to act upon in dealing with the ingredients which he was brought in contact with in manufacturing gas. All coal contained certain elements. He dealt with one class in manufacturing gas, and why should he not extend this skill and knowledge in dealing with that which came afterwards. If that were done it was quite evident that, if gasmen would bring that amount of knowledge to bear upon these residuals which they did in the manufacture of gas, in that proportion would they extract the benefits their residuals were capable of rendering. He held that they had thrown away for many years that which they ought to have used from the commencement, or at least since they ascertained its value for the purpose of extracting those impurities which everybody cried out against. Whether

they adopted the process which he believed to be most simple and efficacious—that proposed by Mr. Hills—or that later one, in which they converted the carbonic acid of the gas into carbonate of soda, or in whatever other form it was done, it was their duty to search for the best means by which they could accomplish the work they had to do, and carry it on to the best results.

Mr. EDWARDS (Taunton) asked what relation did the quantity of salt first used bear to the quantity of bicarbonate of soda produced for sale? It appeared to him that the cost of the salt would be a great item in the calculation.

Mr. GEORGE ANDERSON said they had had that day a new chapter from an old book. It was some years ago since he asked them to look at washers, when they were all afraid of them; and some years since he spoke of the purification of gas by the ammonia contained in it, and he was glad to see scientific men, who understood a great deal about chemistry, were trying to accomplish this. He did not think, however, that it was entirely a chemical question, because they had had, for a series of years, scrubbers and washers of various descriptions, which had done a great deal of good to the gas; but did not sufficiently remove the impurities which they were put there to take out. His belief was that the reason why any impurities were left was that, first, the materials employed were not chemically correct, and next the mechanical appliances were insufficient. It was difficult for him to speak on this subject, because he was interested in it; but he would not blow his own trumpet more than he could help. He had seen last winter a scrubber worked at the Vauxhall station of the Phœnix Company, and Mr. Marshall was acting as a chemical expert in testing its action. He had had the privilege of being there several days in succession, and he found that that gentleman applied, at the outlet of the scrubber, a slightly reddened litmus solution, and the gas passed through that continuously for several days without showing a trace of ammonia; but there was nothing running into the scrubber, for the purpose of removing the ammonia, but a little clean water to the extent of about 12 or 14 gallons per ton. Therefore it seemed to him that it was the want of mechanical arrangement which permitted any of the ammonia to go forward in their scrubbers where water was used. In the scrubber to which he referred, the gas was divided up into the very smallest particles, and by bringing it so intimately into contact with the purifying material the whole of the ammonia was extracted. Mr. Wallace had spoken to him about this, because he also had seen the action of the scrubber, and he intended to use that in preference to the one shown in the diagram, with reversed angle irons. He had little doubt but that if well-purified Hills's liquor were used through a scrubber such as he mentioned, you would get all the different grades of the liquor necessary to produce the result shown on the diagram. In this case the water went from the one to the other; in the scrubber to which he referred there were five vertical divisions, each a water-tight tank doing its own work, and the water passing from the upper to the next, and so on until it came to the lower one. Another thing he should like to mention, although he knew it was treading on dangerous ground. He regretted that the gentlemen who had read papers had never once mentioned the name of Mr. Patterson, and they would not find a chemical paper on gas five years old without such expression in it. There were members who seemed not to know—although some went instinctively in the proper direction—the great necessity of removing carbonic acid from gas before beginning to purify it from sulphuretted hydrogen and other sulphur compounds. It appeared to him, and he had studied the subject for 15 years at least, that they were indebted to that gentleman for a very beautiful discovery, and he thought they ought to acknowledge or dispute it. The next point was, supposing you could, with Hills's liquor, get rid of carbonic acid, which was the difficulty—for the papers said that the liquor still contained a certain amount of carbonic acid—it was quite possible to remove the whole of the carbonic acid from gas by lime, and without producing any smell. If you could not do it in that way, you could not do it in large works in towns. He contended you could remove the whole of the carbonic acid, and the lime had no smell a yard off the purifiers. It was then a question simply of removing the waste lime con-

taining the carbonic acid, which did contain at one time sulphuretted hydrogen, but which had all been driven off, and was now simply carbonate of lime. He would ask any gentlemen who had anything to do with the subject to let liquid purification engage their attention most, because it would be self-acting, and would save them all a great deal of trouble, and bring about the days so beautifully described, when they would have so much healthfulness and economy.

Mr. GEORGE LIVESEY said there were one or two statements made by Mr. Marshall which were not quite in accordance with his experience, especially that to which Mr. Hunt alluded, that by Hills's process of purifying ammoniacal liquor, you did not purify the liquor. Mr. Marshall stated that all the ammonia was combined, but he did not say to what extent it was combined. As his brother's paper had shown, it might be combined with 400 cubic inches of impurities per gallon; but if 40 inches only were combined, it still might be said to be combined, although to a very slight extent. He did not suppose one portion of ammonia would be absolutely combined to its fullest extent, and all the rest in its free state; but the whole ammonia in the purifying liquor was combined with a small proportion of impurities instead of a large proportion. It was quite possible to deprive the ammonia of all its impurities, as he had seen over and over again, only it was not advisable to do so. It required a longer process, and it was cheaper to deprive the ammonia of three-fourths of the impurities, and so to work it over an extra turn, than to deprive it of the whole, and work it not quite so often. It was merely a question of economy. As to the only way of purifying liquor by lime, as Mr. Marshall said, he was quite satisfied you could make rough caustic ammonia by the process he was using. Now came another difficulty about the scrubbers. He had never been able to get clean carbonate of ammonia. Retain the liquor in contact with the gas as long as he pleased, one, two, three, or four days, the whole of the sulphuretted hydrogen would not be expelled. He had found that they had put 10-oz. liquor into a purifying vessel, and the liquor contained, say, 1200 cubic inches of sulphuretted hydrogen to the gallon, and a like quantity of carbonic acid; they had kept that in contact with gas for 48 hours, and its strength was increased from 10 to something like 80 oz., but the sulphuretted hydrogen had still remained at about 1200 cubic inches to the gallon, whilst the carbonic acid had increased to upwards of 10,000 cubic inches. Still they had never succeeded in driving off the whole sulphuretted hydrogen. That might be explained in this way. It was not as if you had an absolutely pure substance to deal with. Would-be chemists often assumed that they were dealing with a simple substance instead of, as they were, with one of the most complex substances possible to find. The gas containing not only carbonic acid but also sulphuretted hydrogen, being brought into contact with this liquor, was continually bringing a fresh increment of sulphuretted hydrogen to the liquor, and he could easily understand that sulphuretted hydrogen would always be present. If you brought carbonic acid only in contact, you might drive off the whole of the sulphuretted hydrogen, as had been proved in some experiments which he had tried. They purified the liquor by bringing it into contact with waste gas from the furnace, containing a large quantity of carbonic acid and no sulphuretted hydrogen, and deprived that liquor absolutely of every trace of sulphuretted hydrogen, so that it could not be detected by lead paper. But then came this extraordinary circumstance. The liquor, which had been deprived of all carbonic acid when put into a scrubber, took out all the sulphuretted hydrogen from the gas. That was an absolute fact. It was an incredible fact, and he had never had it explained; but it was a certain fact that the whole of the gas for six months was purified from sulphuretted hydrogen by this highly carbonated liquor. He was afraid, unless something extraordinary were realized from Mr. Wallace's arrangement, they could not expect to get pure carbonate of ammonia. As to the profit, it reminded one of the old estimates of Mr. Winsor, about a profit of 9d. per 1000 feet for gas sold from the carbonic acid utilised. They could reduce the price of gas to about 2s. per 1000 feet, and still pay good dividends. All he could say was, he should be very glad to see it, but he was afraid there was some element omitted. It was said

that there was about 2½ per cent. of carbonic acid in gas as it left the scrubbers, but he did not find that; and other engineers, with whom he had conversed, informed him they did not find anything like so much as that after the gas had been properly washed. With regard to his brother's paper, he did not wish to say much. The tables would be found interesting, and the points to which special attention might be drawn were the quantities of impurities that the liquor would absorb. He did not think his brother wished to disparage, in any way, Mann and Walker's scrubbers, when he said he had not divided that by ounces, as ascertained by the distillation test. Still there was this fact—that they had not nearly enough ammonia to purify the gas, and if they had to use it, they must use it five or six times over. He was inclined to believe it would answer the purpose to do so, but at any rate he was quite satisfied it could be done. There was one other difficulty in using caustic ammonia; it was such an exceedingly volatile article, when in the caustic state, that the gas carried it forward, and the great difficulty was to keep it in the purifying vessels. You put lime into a vessel, and there it stopped until you took it out, but you might put caustic ammonia in, and when you looked for it it was gone; and you must use a large quantity of water to prevent the ammonia being carried forward. Mr. Hammond told him of a process of his in which he applied the ammonia to the hot gas immediately on leaving the hydraulic main. In that state the caustic ammonia combined with the impurities before it reached the scrubbers, and was washed out in the ordinary way. That seemed to be a promising way out of the difficulty. Still he was in good hopes that they should see light in this matter before long, and these experiments were all tending in that direction.

Mr. HUNT said he did not intend to imply that it was not quite possible to obtain perfectly clean carbonate of ammonia in the first vessel, but he did not think it either desirable or necessary for Mr. Wallace's process. There seemed to be no difficulty whatever in eliminating the whole of the carbonic acid and sulphuretted hydrogen by the ammonia process.

Mr. VERNON HARCOURT wished to put a question to Mr. Frank Livesey. The chief value of the process seemed to be not the removal of the sulphuretted hydrogen, which could not be better done than by oxide of iron, but the removal of the carbonic acid. The important service which this approximately purified ammonia could render was that of removing carbonic acid. There was a great chemical advantage in using that over lime, because the quantity of ammonia which would remove a given quantity of carbonic acid could be produced much cheaper by this process than the quantity of lime which would remove the same amount. He wished to ask, however, whether it was found that, by the adoption of this process, it was possible at the South Metropolitan Gas-Works to remove the carbonic acid from the gas as effectually as before with the use of a smaller quantity of lime? That, he thought, was a measure of the value of the process as now used. One word with reference to what Mr. George Livesey stated as an almost incredible fact. It certainly did not seem to him to be even surprising. If you took a solution of carbonate of ammonia and shook it up with sulphuretted hydrogen, you formed sulphide of ammonium, and set free carbonic acid. If, on the other hand, you took a solution of sulphide of ammonium and shook it up with carbonic acid, you formed carbonate of ammonia, and set free sulphuretted hydrogen. The fact was that the condition of the outlet would always resemble the condition of the gas which was mixed with it, or passed through it. You could increase the proportion of carbonic acid, and decrease the proportion of sulphuretted hydrogen; but you would always have, if the gas contained both, some of both gases in the solution.

Mr. CHANDLER said he was no chemist, but rather followed in the footsteps of Mr. George Anderson, and he might just make a statement with regard to the effect at the Bromley station. Mr. Marriott was conducting experiments with this solution for the purification of gas from sulphuretted hydrogen and carbonic acid, but he omitted to state the vessel in which Mr. Marriott was conducting this experiment. The apparatus in which this Marriott's solution was being tried was known as Kirkham, Hulett, and Chandler's washer. This vessel, like his, had a number of divisions. It

was a horizontal vessel, 17 feet long, divided into ten different bays, each of which was charged with water to start with, and as the gas passed through, the water became strong liquor.

The PRESIDENT, interposing, said they were discussing the principles of the papers read, not the details of different scrubbers.

Mr. HAMMOND (Lewes) said he had recently distilled some caustic ammonia, and brought some in a bottle, and if any gentlemen liked to examine it they could do so. It was readily produced by the process he had in work at Lewes. He not only took the crude ammoniacal liquor from the well and distilled it for the caustic ammonia, but he afterwards recovered the ammonia by washing in suitable vessels, and made a marketable product in the shape of sulphate of ammonia. The process was very effective for the removal of carbonic acid and sulphuretted hydrogen.

Mr. ANDERSON asked if Mr. Hammond used lime.

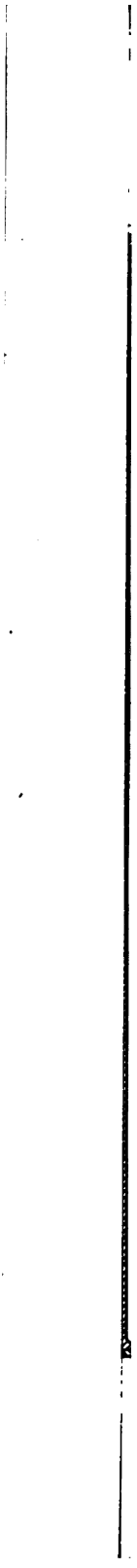
Mr. HAMMOND said he took the crude liquor and put it into boilers, and drove off the foul gases—carbonic acid and sulphuretted hydrogen to a very great extent—through acid in a closed saturator. He made a certain amount of sulphate of ammonia by the process, then shut the valves, and had a closed iron vessel capable of resisting great pressure, into which he drove high-pressure steam. That expelled the air contained in the vessel. Then he mixed cream of lime in a tub, shut the steam from the iron vessel, and produced a vacuum, which sucked, from the top of the tub, the cream of lime; the sediment was not drawn over, but the cream of lime only, which mixed most readily with the water. High-pressure steam was again turned on, and the whole of the contents blown directly into the crude ammoniacal liquor with which he started; then this was agitated in the boilers from which he made the sulphate; then he opened a tap and passed the gas, not again through the saturator, but through an apparatus to regulate the temperature, and from that it passed direct to the hydraulic main, at the extreme end. He could put it into the extreme end of the hydraulic main, either in the form of a vapour or liquid, to mix with the gas; it flowed readily past each dip-pipe, and mixed with the gas as it passed out. He produced a bottle of the liquid, obtained directly from the apparatus before it passed away with the steam into the hydraulic main; also a bottle of the liquid taken out from the hydraulic main, the valve of which had been broken.

Mr. F. LIVESEY said that, with reference to Hills's liquor, it was very evident it would do the work. The liquor, before it was purified, contained 2076 cubic inches of H_2S, and 867 afterwards. The carbonic acid was 2002 cubic inches before, and 489 after, showing that the carbonic acid was reduced to one-fourth, and sulphuretted hydrogen to less than one-half. Mr. Anderson had referred to Mr. Patterson. They all knew Mr. Patterson did make a discovery that lime would not work unless carbonic acid was absent, and this was so well known that he thought it hardly necessary to mention it. It was also found it would not work when sulphuretted hydrogen was present; it would not take out the sulphur compounds if that gas was present in large quantities. Mr. Vernon Harcourt asked a question about the carbonic acid after passing through the washers. They had found there was about one-half per cent., and sometimes less, of carbonic acid, and by that means they were able to do away with the carbonic acid boxes. After the washers, the lime, which the gas came in contact with, acted as sulphide to remove the sulphur compounds; if they did not use Hills's liquor they would require carbonic acid boxes.

Mr. MARSHALL said they were working with Marriott's process with an ordinary 24-inch pipe filled with coke, and they had very good results. With regard to Mr. Anderson's observations, he quite agreed that this process was not entirely a chemical one—in fact, in his paper he had drawn particular attention to the mechanical portion. The angle plate was not a patent, and was open to any one who liked to adopt it. Mr. Anderson also said he used the litmus solution at the outlet of one of his washers. That was the ordinary acid process, and he found good results. He was sorry he had missed naming Mr. Patterson, but his name was well known. With regard to Hills's process they might discuss that for all time, but he was in a position to give an analysis of the figures

obtained from a boiler where it was under trial, and the results of his experience were these—If the liquor was not heated up to a certain temperature, the action would not take place causing separation of carbonic acid, ammonia, and sulphuretted hydrogen. If you heated it a little more, the action did take place to a certain extent, but the washing power or condensing power required to condense the gas again to the normal temperature was very great; but in the samples that were taken, the ammonia existed in the free state only to the amount of ·01024, and the rest as sulphide and carbonate of ammonia. In the face of these figures, he maintained that the action was not complete. Again, admitting it was complete, and that it did drive the carbonic acid into the carbonate of lime, would they be able to dispose of it? There was no carbonate of lime in Mr. Hills's process. The sulphuretted hydrogen was driven forward as oxide; in this the compounds of the ammonia as sulphide of ammonia were used for taking out the bisulphide of carbon compounds. Mr. Harcourt's observations were somewhat similar to Mr. Anderson's—that it was not a chemical but more a mechanical change they had to turn to. Mr. Gore only told them what they already knew—that they must work up the compounds; and any gas companies who wanted to go into this operation would, no doubt, put in a clause which would enable them to start chemical works. But they need not do so; they could sell the products to chemical works. Mr. Hammond's process appeared very feasible; but he used milk of lime, and got carbonate and sulphide of calcium in the same degree, and this was most voluminous and most difficult of disposal. What they wanted was a process for doing away with the liquid sulphide of calcium, and only getting products which would be useful. As to looking at this matter only in a chemical point of view, he was not a chemist, but a gas-maker, and he really found that chemists were the most unpractical men. With regard to Mr. Hammond's observations that the first tower contained a mixture, and that the gas coming into the scrubber contained sulphuretted hydrogen as well as carbonic acid in considerable quantities, that might be so until you got a pump, when you would displace the sulphuretted hydrogen. These experiments showed that over and above the sulphuretted hydrogen driven off there was 0·66 of free sulphuretted hydrogen left in in the liquor drawn from the first tower; and it was not in combination, but existed chemically in the free state. Supposing the decarbonated ammonia did contain sulphuretted hydrogen, it would not matter, because on being placed into the water-tight vessel whereby the carbonate of ammonia was driven off, you might so arrange the condensers that sulphate of ammonium would be condensed in the first vessel, and the carbonate of ammonia driven forward in the last series, so that from them you could draw off the carbonate of ammonium, take up the sulphate in the first, and pop that back again to the gas, so that you would have no smell and no loss of sulphuretted hydrogen. As regarded the desulphurating liquor boxes, patented by Mr. Livesey, there was no doubt the hot furnace gases would so warm up the gases, that the amount of power required to cool the furnace gas would be a considerable item in the expense, and there would be the objectionable carbonate of lime to deal with. The profits did seem enormous, but they were given by the inventors, and when they came to look at the amount of carbonate of soda sold, he did not think they would be found very excessive.

The PRESIDENT said he should like to have said a few words with reference to these papers, not so much with reference to the particular process, which had been very lucidly explained by Mr. Marshall, as on the general question of purification by liquids. But he felt that any observations he could make would not outweigh the consideration that they had very much more work to do, and as there were several papers yet to read, he would not detain the meeting.



THE CORRECT ESTIMATION AND VALUATION OF RESIDUAL GAS PRODUCTS.

By Mr. G. E. Davis (Manchester).

The chemical examination of residual gas products has not, as yet, for purposes of valuation, reached any stage of exactness. I know of no case where a gas-works disposes of its liquor at a fixed price of so much per unit per ton of ammonia, or sulphate of ammonia; but I do know of several instances where gas water is sold on this basis, by tar distillers to chemical manufacturers, to the obvious advantage of the former.

Gas water is only valuable for the ammonia it contains, then why should not a rational system of valuation be adopted, depending upon the amount of active material, rather than a system, barbarous and empirical, like that of selling the gas water at so much per ton of coal carbonized.

To a chemical manufacturer there is a certain risk to run in buying by such a method, and it would be absurd to suppose that as high a price would be offered with a risk as without one, the buyer has the advantage, the seller the disadvantage. The same may be said of the method of selling per degree of Twaddel's hydrometer. Some books state that gas water contains free ammonia. This may be the case, but I must confess that I have never been able to find it; on the contrary, I have never found enough ammonia to saturate the carbonic acid and sulphuretted hydrogen in proportion necessary for the formation of normal salts of ammonia. The acids have always been in excess.

Mr. Child, in a paper read before you in 1876, pointed out the fallacies of the tests in present use; but his explanation, in paragraph 5, is hardly correct. Gas water is of a greater specific gravity than water, because it contains carbonate and sulphide of ammonia, and it is easy, on the large scale, to simply distil this off without lime, when a distillate is easily obtained, 16° Twad., containing carbonate, bicarbonate, and sulphide of ammonium. The fixed ammonia remains in the still. The following experiment will show this clearly:—

Some gas water of 1·025 sp. gr., or 5° Twad., was examined with these results—

	Per Cent.
Ammonia by standard acid	1·270
Ammonia by distillation with lime	1·700
Carbonic acid	1·694
Sulphuretted hydrogen	0·157

100 c.c. of this gas water were heated; effervescence commenced at 182° Fahr.; much gas given off at 206° Fahr.; ammonia and sulphuretted hydrogen evolved at 208° Fahr.; all effervescence ceased at 210° Fahr.; 92 c.c. were left, which were made up with pure water to 100. The liquid was then 1·007 sp. gr., or 1½° Twad., and contained—

	Per Cent.
Ammonia by standard acid.	0·85
Ammonia by distillation with lime	0·79
Carbonic acid.	0·11
Sulphuretted hydrogen	Nil.

Equivalents ammonia liberated, 5·41; equivalents carbonic acid and sulphuretted hydrogen liberated, 4·06; formula of salt liberated $(NH_3)_4$ $(CO_2)_3$, in which a little of the carbonic acid was replaced by sulphuretted hydrogen—constitutional water, of course, in addition.

But to return to the methods of estimation now in use. The saturation of the gas water by sulphuric acid should never be adopted as a means of valuation at any gas-works, as the foregoing experiments prove. The gas

water, if sold by this test, would contain apparently only 1·27 per cent. of ammonia, whereas it really contained 1·7 per cent. or nearly 30 per cent. more.

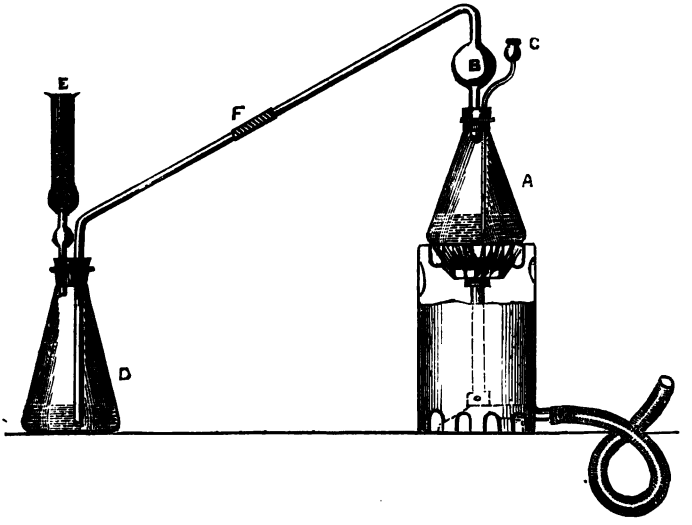
Having said so much against the methods now in use, you will be inquiring how should it be done; and, in reply, I must say that first it is necessary, before fixing upon any method, to see what gas liquors generally contain. The following is the result of an analysis of gas water which I made some time ago:—

Sp. gr. 1·0362 = 7½° Twad.

	Grammes per Litre.
Ammonia by standard acid	29·00
Fixed ammonia	5·08
Sulphuretted hydrogen	9·23
Carbonic acid	31·46
Hyposulphurous acid	1·21
Ferrocyanic acid	Traces.
Sulphocyanic acid	13·94
Carbolic acid	Traces.

Gas waters vary much in their composition, but they always contain the above ingredients in more or less proportion. Some are rich in carbolic acid and very poor in sulphocyanides, while in others the ferrocyanide is so high that it would pay for extraction.

The method I am about to describe is somewhat similar in kind to that proposed to you in 1876 by Mr. Child, with some little variations, which are necessary to ensure ease and celerity in working, and accurate results. The whole of the ammonia is obtained from the liquor under treatment, and calculated to sulphate of ammonia, in order to obtain a larger figure for valuation purposes, and I hold that it would be much more satisfactory to sell liquor, in future, at a fixed price per unit per centum for each ton of gas liquor sold.



The above sketch shows the apparatus employed, which is of the simplest kind—measuring flask, 250 c.c.; a burette and two pipettes are also needed. Some milk of lime, 10° Twad., a standard solution of sulphuric acid of such a strength that 100 c.c. neutralize 5·3 grammes of pure carbonate of soda, and a standard solution of caustic soda of the same strength, with a solution of litmus, are all the solutions required.

In order to avoid the use of a balance for weighing off the ammoniacal liquor, I have constructed the following table, showing the quantities to be taken in cubic centimètres of liquor at various degrees on Twaddel's hydrometer, to be equal to the 66 grammes which have to be taken:—

Deg. Twad.	C.C.	Deg. Twad.	C.C.
1	65·67	4½	64·55
1½	65·64	5	64·40
2	65·34	5½	64·23
2½	65·18	6	64·07
3	65·02	6½	63·92
3½	64·86	7	63·76
4	64·70	7½	63·61

The operation can be better described by giving an instance. Gas liquor 6° Twad. 64 c.c. of the gas liquor (or 66 grammes) are taken from the sample by means of the pipette, and placed in the 250 c.c. measuring flask, then made up to the mark with water and well shaken. One-tenth of this, or 6·6 grammes are then placed in the distilling flask, A, and the cork containing the bulb, B, and the funnel, C, fitted to it as shown on diagram. The receiving flask, D, is then partially filled, as shown, with 20 c.c. of the standard sulphuric acid, which is run in through the scrubber, E, filled with glass beads. The acid is then coloured with litmus. 100 c.c. of water, and 20 c.c. of the milk of lime are now added to the distilling flask, the flask brought to a boil, and kept boiling for half an hour. The bulb tube, B, is placed as a safeguard against frothing, which sometimes happens during the boiling, anything condensing in this bulb runs back into the flask again. After the expiration of half an hour, all the ammonia will have been driven off into the flask, D. The apparatus is, therefore, disconnected at F; the tube, E, well washed into the flask, D; the standard soda solution added until the litmus remains neutral, and is no longer red nor blue. The number of cubic centimètres of alkali or soda solution subtracted from the 20 c. c. of acid used gives the per centage of sulphate of ammonia without any calculation.

Thus 64 c.c. of gas liquor, at 6° Twad., were diluted to 250 c.c., and 25 c.c. of this put into the distilling flask, and 20 c.c. of standard acid into the flask, D; 100 c.c. of water and 20 c.c. milk of lime were then added to the distilling flask, and boiled for half an hour. E was then washed down into D, and standard acid added, of which 9·9 c.c. were required; therefore the gas liquor contained ammonia equal to 20·0 − 9·9 = 10·1 per cent. of sulphate of ammonia.

Milk of lime is used because caustic soda is not without action upon the cyanides which the liquor contains.

The following results of the examination of gas waters may not be uninteresting:—

Source.	Deg. Twad.	Per Cent. Sulphate Ammonia.	Per Cent. NH_3 by Stand. Acid.	Per Cent. CO_2	Per Cent. H_2S.	Eqs. NH_3 to CO_2 + H_2S.	Value at 4s. per deg. Twad.	Value at 2s. 6d. per Unit. Col. 2.
Stalybridge	4½	5·5	0·90	1·330	0·154	1·45	19s. 0d.	13s. 9d.
Macclesfield	6	8·0	1·10	1·410	0·034	1·97	24 0	20 0
Bury	5	6·6	1·275	1·694	0·157	1·74	20 0	16 6
Salford	6	9·6	1·84	2·110	0·154	2·00	24 0	24 0
Oldham	6¾	9·0	1·94	3·056	0·128	1·56	27 0	22 6
Stockport	6	6·8	1·10	2·300	0·230	1·09	24 0	17 0
Runcorn	5½	6·6	1·00	1·385	0·018	1·84	22 0	16 6
Private Gas-Works	6	10·1	1·48	2·508	0·484	1·22	24 0	25 3
Middleton	7	11 6	2·60	3·984	0·149	1·61	28 0	29 0
Blackburn	4½	7·6	1·17	1·560	0·050	1·86	18 0	19 0
Congleton	4½	7·76	1·62	2·040	0·190	1·83	18 0	19 4
Dukinfield	6¾	11·48	2·36	2·750	0·160	2·00	27 0	28 8
Rochdale	5½	9·38	1·98	2·620	0·190	1·77	22 0	23 5

The sixth column shows that there was no free ammonia in any of them, and the last two columns show the values; first calculated at 4s. per degree Twaddel per ton, the second at 2s. 6d. per unit per cent. of sulphate of ammonia per ton of liquor delivered into a manufacturer's works—its present value.

Turning to another residual product of gas-works—*i.e.*, tar—I may say that as yet there is no ready laboratory method for the valuation of this, and results obtained in the laboratory would, I am afraid, be of but little use, as it held that some of the products obtained from a tar-still were not originally present in the tar, but formed in the still during the process of distillation by the action of some of the ingredients upon others there present.

Last, though not least, comes the question of the analysis and valuation of spent oxides, and I must say that all the methods that have been employed for this purpose (as a chemist I am almost ashamed to say it) in general use are, and have been, incorrect—grossly incorrect at times, giving no idea of the value of the article. Not only the available sulphur has been wrongly estimated, but a simple thing like an ammonia estimation has been so bungled over by many a chemist, that I have known serious commercial difficulties and wrangling owing to the faulty method the chemist employed. I cannot blame the commercial men in these matters, even though they are rather sharp in taking advantage of the faults of the "high" or "low" analyst as may serve their turn; but I do blame chemists for not acquainting themselves more fully with the details of their subject, and this and many other questions of a similar nature only show one more clearly the deplorable state of technical chemistry in this country, and show also how little exertion is made by technical chemists to help to drag their profession out of the mire.

In the *Chemical News* of Jan. 16, 1874, p. 30, I first pointed out that the value of spent oxide did not entirely depend upon the amount of sulphur which it contained; and it was customary then to perform the analysis by oxidizing the sulphur to sulphuric acid, and finding the difference between that as "total sulphur," and the sulphur existing as sulphates. This method was, however, abandoned for the bisulphide method, as it is called, which is most incorrect as a general method of analysis, for, as a rule, it not only estimates the tarry matter as sulphur, but it cannot show the variations in the quality of the article, which any test for technical purposes should do. It is possible to make such a spent oxide show abundance of sulphur by the "bisulphide test," yet a vitriol manufacturer could not produce any sulphurous acid by burning it.

A test, to be of any value, should be such a one as would show even small variations between various samples, and one which would point to the exact amount of any injurious element introduced which would detract from the value of the spent oxide.

After some years of experience in the analysis of spent oxide, I devised a method which overcame all difficulties, which is termed "the combustion method." This method is very fully described in the *Chemical News* for Oct. 26, 1877, p. 188,* and as it is rather a lengthy description, I will not weary you by going into details; suffice it to say that the sample of oxide is first washed and dried, and then burnt in a stream of dry air in a combustion furnace. Though the process is very rapid, simple, and accurate, it could not be described so well as exemplified, and I should, therefore, be most happy to show any persons the process working, or give them any instructions so that they may work it themselves.

It is not, however, necessary that a gas manager should trouble himself at all with sulphur analyses. I have pointed out in another paper that it is only necessary to determine the amount of oxide of iron in order to see whether an oxide is spent or not, the estimation of the sulphur may well be left to the analytical chemist when the sample is to be sold.

The moisture in spent oxides is very easily estimated. A given quantity—say 5 grains—is dried in the water-bath until it ceases to lose weight, which generally happens in about two hours. The loss in weight, multiplied by 20, gives the moisture per cent.

* Reproduced in JOURNAL OF GAS LIGHTING, Nov. 20, 1877, Vol. XXX., p. 802.

The ammonia has now to be estimated. Spent oxides usually contain the following salts of ammonia :—Chloride, sulphate, ferrocyanide, sulphocyanide, and some prussian blue. Until quite recently the usual plan for the estimation of the ammonia was to boil a weighed quantity of the oxide with caustic soda, in the flask before described, and collecting the evolved ammonia in standard acid. This method is extremely erroneous; for, not only ammonia from the salts of ammonia is evolved, but the chemist who operates thus produces ammonia from the ferro and sulphocyanides, which these oxides often contain in abundance.

Oxide, when spent, is valuable only for the salts of ammonia, which, being soluble in water, should be easily washed out. The sulphur present is, of course, also valuable.

The only correct way to analyze spent oxides for the ammonia they contain is as follows, the results being brought out as sulphate for valuation purposes :—

Take 6·6 grammes of the oxide for analysis, and place it for two hours in the water-bath to dry—this is for the purpose of making it wash readily, and to prevent the prussian blue from washing through the filter. This quantity is then digested with water, and the whole brought into a filter; the residue being washed until free from ammonia. The filtrate is then placed in the distilling flask, A, and the operation conducted precisely as described for gas water, the number of cubic centimètres of standard acid used, less the cubic centimètres of soda, gives the per centage direct of sulphate of ammonia, without any calculation. On no account must the oxide itself be boiled with caustic soda, and those chemists to whom I have pointed this out all agree with me in this respect.

I have lately had some correspondence with Dr. Voelcker upon this subject, and he has given me permission to state that he finds my argument correct, and also says that in future he shall always adopt the method of washing out the salt of ammonia, and estimating the ammonia in the watery solution.

Mr. Edwards asked if the ammonia could be estimated as chloride instead of sulphate.

Mr. Davis replied that the ammonia could be estimated quite easily by several means. It was driven off, and kept as ammonia. It was calculated as sulphate on purpose to have a fixed standard of valuation.

SOME NOTES ON THE CONSTRUCTION OF RETORT-SETTINGS.

By Mr. G. E. Stevenson (Peterborough).

The setting of retorts has formed the subject of so much discussion, and been so ably considered in papers read at former Meetings of this Association, that I should not have felt justified in occupying your time with a paper on this question, were not the retort-setting so all-important a feature in the construction and working of gas-works, and one which, notwithstanding the attention which has been devoted to it, is still far from being exhausted, or even satisfactorily settled, either as regards the principles to be observed, or the form in which these are to be carried out. Having myself obtained very satisfactory results from settings which have been constructed with a view of embodying, so far as possible, principles which I believe to be correct, I have ventured to bring forward a short paper for your notice, comprising a description of the settings and a statement of the principles I had in view in constructing them.

In the first place, I will take it as an axiom that the primary object to be held in view in constructing a setting of retorts is to get as much gas as possible out of each ton of coal carbonized, of the quality prescribed by the Act of Parliament under which the undertaking is worked. This, I think, all will agree with, for, though some may consider it undesirable to obtain so large a yield of gas per ton as to necessitate the use of cannel, or other carburetting agent, to bring the gas up to the standard quality, every one will see that, given a certain quality maintained, every 100 feet of gas extra out of a ton of coal is a direct gain, which may be estimated according to the cost price of the gas produced.

I will also state my opinion at the outset, that no economy in other directions, such as a lengthened durability of retorts, saving of fuel, or cheapness of construction, will compensate for a reduced production of gas per ton of coal carbonized.

Holding these principles in view, it appeared to me that the heat generated in the furnace of a retort-setting is often dissipated throughout a large quantity of brickwork, which is introduced into the setting under the plea of being necessary for the proper support of the retorts. It is a common thing to see a very intense heat in the furnace of a retort-setting, and, at the same time, an indifferent one in the retorts. This is most commonly the case with settings of seven retorts, in which the middle retort is situated immediately over the fire, and supported by a continuous arch having nostrils, through which the heated gases of combustion pass into the setting. The same thing exists in a lesser degree when the arch is not continuous, but divided by spaces, as where cross walls are used, and with the additional disadvantage that those portions of the retort which are left exposed to the fire are rapidly destroyed.

The reason of this inequality between the degree of heat developed in the furnace and that attained in the setting itself is to be found in the absorption of the heat by the surrounding brickwork, and its dissipation over a large area of heat-conducting material; for, given a certain quantity of heat generated—that is to say, a certain number of heat units evolved, and the intensity of the heat developed will be in inverse proportion to the extent of the medium presented for its absorbtion.

Now, I am aware that some managers are of opinion that it matters little how much internal brickwork a retort-setting contains, for, say they, the heat which the brickwork absorbs is given out again at a future point in the process of working, and a large quantity of heated brickwork acts as a reservoir of heat, giving out and taking in, according to the necessities of carbonization. This is only true to a limited extent, because fire-clay is

a bad conductor of heat; and, while a portion of the heat absorbed by the brickwork may be imparted to the retorts in time of need, by far the greater part of it finds its way, by radiation from the surface of the brickwork, through the damper direct into the main flue. With proper working arrangements, also, such a reservoir of heat presents no appreciable advantage, while the prejudicial effect of such construction, in diminishing the intensity of the heat developed, is easily made evident. A little consideration is sufficient to show that it is not the total quantity of heat evolved which is the criterion of the gas-making capacity of a retort-setting, but the degree of intensity developed, or the pyrometrical effect of the combustion. Experience shows that a much larger quantity of gas is produced from a ton of coal if the distillation be conducted at a high heat than at a low one, and also that if the value of gas as an illuminating agent be expressed in pounds of sperm, a far better result is obtained with a high heat than with a low one, for the obvious reason that with a high heat much of the light-giving hydrocarbons is converted into permanent gas, which would otherwise remain in the residuals. In addition to this, the higher the heat, the shorter the period required for carbonization, and the greater the work done by each retort within a given time.

What we want, therefore, is to get a degree of intensity of heat in the settings more nearly approaching that of the furnace, and the way to do this is to oppose as little obstruction to the passage of the heat to the retorts as possible, and to present to the currents of heat the least possible absorbing surface other than that of the retorts themselves.

In carrying out these views, so far as the form of my retort-settings would allow, I altered four settings last year in accordance with the drawings exhibited. The retorts in this setting are oval shaped, 9 feet long internally, and 21 by 15 inches in section, and the settings are placed back to back in the centre of the retort-house. The alterations made in the setting of the retorts were as follows:—In the place of arches under the centre retort corresponding with the cross walls, I set the retort on a saddle, A, constructed of four blocks, each 1 foot 9 inches long, and butting together, the joints being situated over the centre of each transverse support. The transverse supports are carried up from the sides of the furnace and projected over in courses, each course projecting 1½ inches, the projecting courses being constructed of blocks 9 inches square and 3 inches thick. The unsupported central portion of the saddle is 9 inches in width. The saddle is 4½ inches thick at the centre, and is rounded at the sides, between the supports, to obviate cramping the passages for the currents of heat.

The side retorts are supported by blocks, as shown, and the upper retorts rest on saddles placed upon the middle retorts, and a brick on edge pier placed between them. The spaces between the lower and upper side retorts are blocked by a single course of bricks set in the centre line of the retorts. The blocks, H, stop the passage of the currents of heat to the sides of the setting except for a length of 14 inches from the back wall, where they are discontinued.

The flues under the lower retorts are divided by a midfeather for the better support of the retorts, but the draught is taken through both divisions in the same direction simultaneously, there being a communication to both sides of the flue at the front end as shown. These flues deliver the currents into a back chamber, 1 foot wide, in which they ascend to the main flue at the top. There are three sets of transverse supports, each of which is 9 inches thick, and the spaces between the supports are about 1 foot in width.

The furnace of this setting is 1 foot wide at the bottom, and 18 inches at the top; it is filled with fuel to a depth of two feet, and has a capacity of about 10 cubic feet. The fire-grate is 3 feet long, and reduced by the dead plates at the side to a width of 9 inches. The two fire-bars are of 1¼ inches square iron, and the spaces left for the passage of air are 2 inches wide. There are two furnace-doors, the upper one for filling and the lower one for clinkering, and an inclined dead-plate 10 inches long is fixed between the door-frame and the fire-bars, which hinders the fierce combustion of the fuel in close proximity to the furnace-doors. The front wall of the setting is 14 inches thick.

The work done by these settings is as follows:—Each setting, when at full work, carbonizes 8½ tons of coal in 24 hours, and produces about 85,000 feet of gas, or 5000 feet per mouthpiece. The charges are about 2 cwt. each, and of five hours duration. The average quantity of gas produced is rather more than 10,500 feet (average of half year ending Dec. 31, 1877, equalled 10,580 feet) per ton of coal, and the quality of the gas about 16 candles, as tested by Sugg's No. 1 "London" burner. The coal carbonized is exclusively Silkstone coal, no cannel whatever having been used. The fuel account is 23 per cent. of the coal carbonized, as weighed into the furnaces.

Before the settings were altered to the present design, the retorts were set with arches over the furnace, and with four cross walls, the walls and the spaces between them being alike 9 inches wide. The position of the retorts was the same, and the furnace was of the same dimensions, except as regards depth, the arch preventing it from being so deeply filled as at present. The average make of gas was then about 10,200 feet per ton, and 4000 feet per mouthpiece per diem, the fuel account being 26 per cent. As out of seven settings employed during last winter only four were constructed on the new plan, the results which I have given may be considered to be below what could have been obtained if all the settings at work had been of the new design; but they are sufficient to show the improvement gained as the result of the alteration, and to prove conclusively that an excess of brickwork in a retort-setting is prejudicial to the attainment of good results.

In order to show how groundless is the supposition that it is necessary to have plenty of brickwork to act as a reservoir of heat to equalize the heat of the retorts according to the stress put upon them, I will just mention that the retorts in my setting heat quite uniformly, the bottom retorts being equally hot with the upper ones, and there is no appreciable variation in the heat at any time during the 24 hours, except just after clinkering, when a slight reduction takes place. The retorts are charged in three separate lots at equal intervals in the five hours, and thus a uniformity is maintained in the work which the setting has to do.

The results obtained by these settings are not very extraordinary or surprising, but I think that I may claim for them that they are good results, and such as may be taken as a very fair standard of what a retort-setting ought to perform. This being the case, it may be of interest to note the proportions which the area of retort surface bears to the coal carbonized, and the proportions of the furnace and flues in relation to the same, and therefrom deduce some rules for future guidance in the setting of retorts.

In these settings, the area of heated retort surface may be estimated at 880 square feet; in making which calculation I take the circumference of the retorts at a line passing round the retorts midway between the inner and outer diameters, and I allow something for that portion of the retort next the mouthpiece, and embedded in the front wall of the setting. The quantity of coal carbonized in these settings in 24 hours I have stated to be 8½ tons. This is about one ton per 100 square feet of retort surface, and as from each ton of coal 10,500 cubic feet of gas are produced, each square foot of retort surface produces rather more than 100 cubic feet of gas in 24 hours.

The quantity of coke consumed as fuel in each furnace is 16 cwt., or 1792 lbs. per day of 24 hours. As coke contains 90 per cent. of carbon, this is equivalent to 1613 lbs. of carbon burnt in 24 hours. One pound of carbon requires the supply of 2·66 lbs. of oxygen for its combustion, and as in the atmospheric air there are 3·38 lbs of nitrogen to each pound of oxygen, 11½ lbs. of air will be required for each pound of carbon, or $\frac{1613 \times 11{\cdot}5}{1440} = 12{\cdot}88$ lbs. of air supply per minute. One pound of air is equal to 13·08 cubic feet in volume at the normal atmospheric pressure, therefore, 167·8 cubic feet of air must pass through the fire-bars per minute, or rather less than 3 cubic feet per second. The area of the fire-grate is 3 square feet, and that of the air spaces in the same is 1½ square feet; the air, therefore, passes into the furnace at a velocity of 2 feet per

second. The flues under the bottom retorts have a collective area of 2¼ square feet, therefore equal to that of the air spaces in the fire-grate.

The draught in the furnaces is sufficient to create a thorough combustion and a very intense heat, but no roaring is heard, and there is no cutting away the brickwork or retorts at points where angles occur, or contractions take place in the air passages. From experiments made, I have found the draught in the furnaces to equal a vacuum of 0·07 of an inch of water; in the bottom flues it increases to 0·12 of an inch, and in the main flue it is 0·20 of an inch. The dampers are kept open about 8 inches in the regular course of working.

From these particulars, the following rules for approximate proportions in the construction and working of retort-settings may be deduced:—

1. A retort-setting should carbonize one ton of coal per 100 square feet of retort surface per diem.
2. Every square foot of retort surface should produce 100 cubic feet of gas per diem.
3. The capacity of the furnace should be regulated by the extent of the retort surface to be heated, and, when coke is used for fuel, may be ascertained by dividing the number of square feet of retort surface by 33, which will give the capacity of the furnace in cubic feet.
4. The retort surface divided by 100 will give the area of the fire-grate, and the fire-bars and spaces should severally occupy half this area.
5. The flues, under the bottom retorts, should have a collective area equal to that of the fire-grate spaces. This should be the case with all openings for the passage of the heated gases, except the opening into the main flue, where the damper is situated, which, if the chimney be of any considerable height, need not have so large an area.
6. To heat 100 square feet of retort surface, 1 cubic foot of air supply per second is required, and the main flue and chimney, as well as the retort-settings, should be constructed with due regard to this principle.

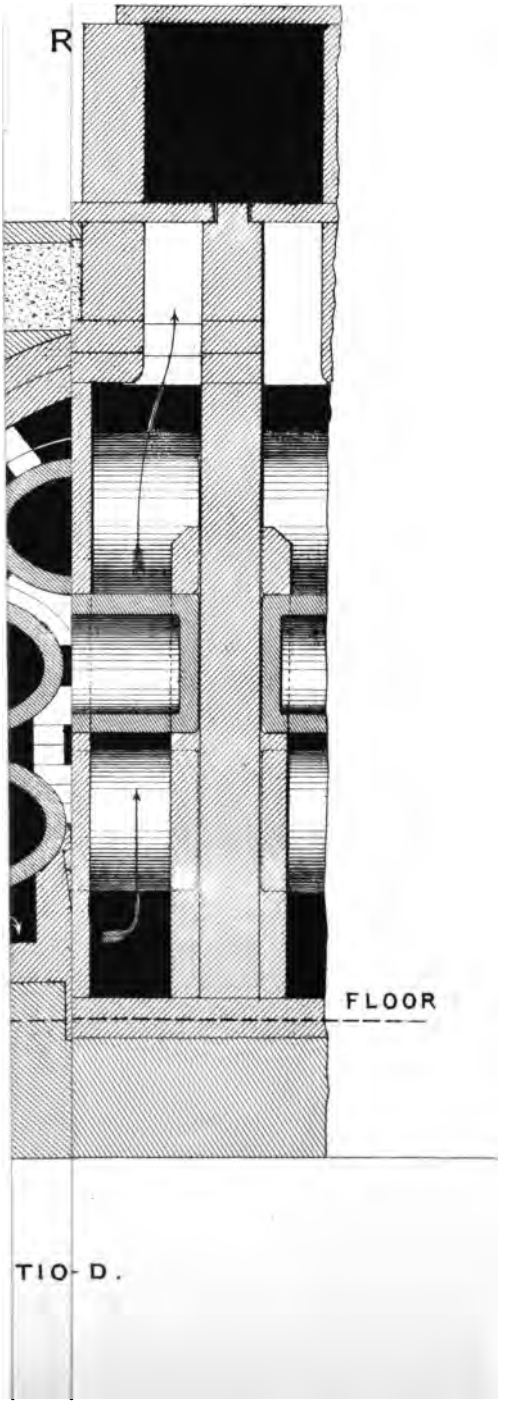
As a practical remark, in addition to the above rules, it may be said that to obtain a uniform heat in a retort-setting, it is important to have plenty of room in the setting for the passage of the currents of heat, and to allow ample area in the fire-grate and flues. When this is not the case, an unnecessarily strong draught is required to be exerted by the chimney to assist the combustion of the fuel, and the cutting draughts in the flues which occur rapidly destroy the retorts and brickwork. The heating of the retorts is also irregular, those situated immediately over the furnace being very hot just in the middle, and those at the sides and bottom being indifferently heated. It is also important that the front wall, and all other exterior walls of the setting, be as thick as it is convenient to make them—14 inches being much better than 9 inches for the front wall of a retort-setting.

In conclusion, permit me to say that, although I have defined in the above manner some of the proportions to be observed in the construction of retort-settings, I do not put forward my setting as a model, representing the best form of retort-setting, nor do I imagine the proportions given to be the best attainable, or even existent. How wasteful of fuel the present system of setting and heating retorts is, may be perceived when it is said that, although the pyrometric effect of coke is theoretically about 2200° C. (4664° Fahr.), in practice about 1100° C. (2332° Fahr.), or just half this effect, is obtained in retort-settings; and, of the heat produced, not more than half is made use of, for the gases of combustion leave a retort-setting, and escape into the main flue, at a temperature between 500° and 600° C. (1000° to 1200° Fahr.)

Still, so long as no better system of carbonization is known, I believe that much may be done to improve the existing one, by ascertaining and defining the proportions which should be observed in the construction of retort-settings, as well as by inventing new methods of working them; and if I have been enabled to add the smallest quota towards the accomplishment of this end, my purpose will have been attained.

Mr. WILSON said he had not heard the whole of the paper, and could only judge by the diagram and concluding portion that a very important matter had been taken up. The diagram represented a furnace with upper and lower doors—one for firing and one for clinkering—and he supposed the carbonic oxide would be converted at the top of the furnace into carbonic acid. The only question with him was in how far those furnaces were the best for practical use. He found in practice that the seventh retort was an element of weakness, and that a very strong heat in the combustion chamber over the furnace had the effect of quickly burning out the support of that retort, and the other two at the top being dependent upon it, the setting fell down. With six retorts instead of seven, he thought it would be a very successful setting. He had built one which very much resembled it, and had every reason to be satisfied with it, but he had not brought it before the Society, because he did not know how far it would be successful.

The PRESIDENT suggested that Mr. Carpenter's paper should be read before the discussion was carried further.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IMPROVEMENTS IN CARBONIZING APPARATUS.

By Mr. W. T. CARPENTER (Sheerness).

The subject of improvements in carbonizing is one that every gas engineer is more or less interested in; and although much has been said and written on the subject of mechanical stoking where machinery has been made to take the place of manual labour, I am not aware that a paper has been read touching upon any of the points relative to the apparatus hereafter to be explained.

It is not necessary that I should give a full description of all the retorts and ovens that have been designed and patented, used and in use, and the various processes for carbonizing coal for the manufacture of illuminating gas. Such a course would occupy too much time. I, therefore, intend only to treat upon those methods which may be necessary for reference. Many persons, besides gas managers, have been engaged on this subject, and have had fancies for novelties, upon which large sums have been spent in the construction of apparatus; to convert coals into illuminating gas, and likewise reduce the cost of production.

In the earliest days of gas manufacture, the attention of engineers was given to the importance of economy in the retort-house, with a view of reducing the heavy, hot, and exhaustive duties of the stokers engaged in drawing and charging the retorts. With this object, Clegg introduced his discharging and revolving web, on which the coals were made to pass through the retorts by means of a flat iron chain; and although it is recorded that excellent results were obtained both in quantity and quality of illuminating gas, the scheme was abandoned on account of the destructive nature of the hot coke on the iron chain. This system was continuous, and came very near to perfect carbonization.

A Mr. Hobbins, of Walsall, also patented a system of through retorts, where a series of rakes were used to level the coals, and push out the coke but, as with Clegg's revolving web, the heated coke destroyed the rakes, and not finding it so economical as was expected, it was abandoned.

We have it also recorded that Mr. Brunton, when Engineer of the Birmingham Gas-Works, had a discharging system of retorts, whereby the coals were thrust into the retort, the coke ultimately falling into a water cistern, from whence it was collected. The inventor had 60 retorts at work on this system at one time, and claimed an increase of 35 per cent. in volume, also a saving in labour. The important increase said to have been obtained by these pioneers in gas manufacture must not be too lightly passed over. Had these statements been made at the present time, with clay retorts worked at high heats and with improved exhausting machinery, the surprise would not be so great; but we may infer that, as iron retorts were used in both Clegg's and Brunton's systems, there are some reliable data for the inquiring gas engineer to work upon, and we have as recorded certain facts which lead us to believe that the last-named processes were only partial failures. We, therefore, find there is still room for improvement in the retort-house, for the stokers have yet to perform their duties. It is true, machines and improved stoking tools have been introduced and placed into the stokers hands, but the work of drawing and charging the retorts has still to be performed.

The advantage to be derived by the use of machinery is obvious, and, whether in gas-works or any other manufactory, its introduction is with a view of reducing the heavy labour and cost of production. How far this can be carried out in the retort-house is a matter yet to be solved, and it behoves the gas engineer to introduce machinery wherever it is practicable.

I have for many years directed my attention to the subject of improve-

ments, and have constructed an apparatus which promises to go far towards reducing the heavy labour of the stoker, having the novelty of being nearly self-acting and continuous, having gravity for its principle, giving equal results with less labour, and accomplishing the most disagreeable part of a stoker's duty.

The apparatus consists of a double bench of retorts and oven combined, the retorts being open at the back end, and communicating with the oven into which the coke is discharged, and where, after remaining some time, it is allowed to fall out.

The engravings show a Front Elevation, Side Elevation, and Transverse Section of the apparatus. A is the hopper, into which the coals are placed; B is a pulley; C is a vertical shaft, with arms, to keep the coals from clogging; and D is a worm on the driving-shaft. E is the mouthpiece, and F F are wheels which give motion to the screws or regulators, X X. H H are the retorts, and I I are the openings pierced in the retorts for the exit of gas to ascension-pipe. J is the oven into which the coke is discharged; K is the main flue which heats the oven, and L and N are eduction-pipes for carrying off the gas. M is the coke outlet, into which is fitted a door, opening downwards.

The action of the apparatus is as follows:—Coals are placed in the hoppers, and descend into the mouthpiece, and falling on the screws are gradually pushed into the retort, becoming soft by means of the heat, and forming themselves into the shape of the retort. They thus completely fill the small end, and keep back the gas; and as the coals are screwed into the retort the charge assumes a shape, so as to half fill the interior area, the gas finding its escape by the outlet, I. The motion is continuous, and the charge reaching the end of the retort becomes coke of a fragile nature, falls into the oven, where any gas remaining in it is driven off, and escapes from the top of the oven by the pipe, L. After the coke has remained in the oven some time, it is allowed to fall out, by opening the door for that purpose. The door is then immediately closed in readiness for the next charge.

The apparatus having been practically at work at different times, opportunity occurred for testing its merits. The trials were conducted in the following manner:—All other retorts were struck and drawn, and the valves shut, the index of the station-meter taken, and the hoppers filled with coals. When the apparatus had been at work for the time appointed, the index of the station-meter was again taken, coals weighed to refill the hoppers, and the coke discharged and carefully measured.

Trial No. 1.—Time eight hours, exhauster worked at 3-10ths pressure in retorts, the hydraulic dip dispensed with, and bye-pass in use. Coals carbonized, 12 cwt.; gas registered, 6210 cubic feet, or 10,350 cubic feet per ton; coke discharged, 21 bushels; illuminating power, 13½ candles. When this trial took place the apparatus had been at work 29 days.

Trial No. 2.—Time eight hours, exhauster worked at 2-10ths pressure in the retorts. Coals carbonized, 9½ cwt.; gas registered, 5200 cubic feet, or 10,947 cubic feet per ton; coke discharged, 18 bushels; illuminating power, 14 candles.

Pelaw Main coal was the description used.

There is a speciality in connection with this apparatus, to which I beg to call your attention—viz., the principle on which it is constructed—that is, gravity; for on the coals being once placed in the hoppers, which can be done by means of a Jacob's ladder or elevator at a trifling cost, they are kept continually moving until they reach the oven. This moving causes the gas to escape from the interior of the charge, greatly facilitating the carbonization of the coals.

It is not necessary to crush the coals, as this must be regulated by the pitch of the screw. For instance, a 4-inch pitch will take a piece of coal the same size, and in well-regulated gas-works no larger pieces should be used in any process. Should it happen that a larger piece finds its way to the screw, it will get crushed by it as it revolves, or it slips the screw out of action. This circumstance will be seen by the man in charge, but it seldom happens, and is soon remedied.

Again, the manufacture of coal gas, under any process, deposits a layer of carbon in the retorts, and to remove this carbon is generally a difficult

task, and not a few retorts are injured and destroyed by the process. If not injured by the chipping bars, the retorts are allowed to stand open, exposed to the atmosphere for several days, in order to burn it off. Should it be necessary to clean the carbon off in this setting, the front plugs are taken out of the mouthpieces, and the charge pushed down into the oven and discharged; the door is then left open, when a strong upward current of air passes through each retort, and the carbon is effectually removed in a few hours.

I have simply stated these facts, to elucidate, if possible, the advantages of the system.

In conclusion, I may state that the apparatus is erected at the end of the retort-house—a great distance from the engine—motion being transmitted by means of ordinary chains and pulleys. Very little power is required to work the setting.

To better illustrate the system, there is a model, and a screw which has been used during the time the setting has been in action, both of which you may inspect, also a sample of coke.

[The discussion which follows has reference to the paper by Mr. G. E. Stevenson, on "Some Notes on the Construction of Retort-Settings," as well as to the above paper.]

Mr. BARRATT (Grantham) said there were several questions required to be asked with regard to Mr. Stevenson's setting. This was the very life of their system. They either lived by a proper application of their retorts, or died by the abuse of them; and it was essentially necessary to ascertain whether there was any advantage in this method or not. He thought a great deal would depend on the quality of the coal used; and their Scotch brethren had an advantage here, because they had a better quality of coke from the north country coal, which would evolve a greater quantity of heat than any other coal. If these retorts could be set in such a way that they would last for a considerable time with a minimum quantity of coal per ton carbonized, they would be in a position to judge of the benefit of the system, and no one could confer more benefit on the Association than by bringing out the best system of setting retorts.

Mr. GORE believed that every disease required its own remedy; and so every class of coal would require a special system of treatment; as the system which was perfectly applicable to one class might be perfectly inapplicable to another. He thought it was from this fact that they had such conflicting statements made as to the results obtained. It was quite certain that all the coal-fields of England produced coal which might manufacture light-giving gas; but the quantity of it would vary, to a great extent depending on the position of the stratification of coal and the source from which it was obtained. Suppose they had a retort-setting of that class, and had to deal with some of the cannel coals of Scotland, the necessary consequence would be that, instead of getting from 10,000 to 11,000 feet per ton, which a Scotch manager would expect to get, he would probably get no more than 7000 or 8000 feet, simply because the amount of heat necessary to evolve the gas from its cells in the coal was not supplied rapidly enough. Again, they might be in a district where the gas was the product most required, and where they could afford to expend an extra bushel or two of coke with advantage. It was quite certain that a furnace which would consume a large quantity of coke, and give out a greater quantity of heat in a given time, was more applicable to such a district than one with slower combustion, less product of heat, and, consequently, a smaller result during that given time. In judging, therefore, the value of any system of retort-setting, they must be guided by a variety of circumstances, and thus the engineers of each locality must select for themselves. He was satisfied that if they would deal with this matter on a different footing from what they had hitherto done—if they abondoned, to a certain extent, the "follow-my-leader" principle in using any system, and were only guided by the lessons it taught, they would gain great advantage. Mr. Carpenter had read a most valuable paper on continuous

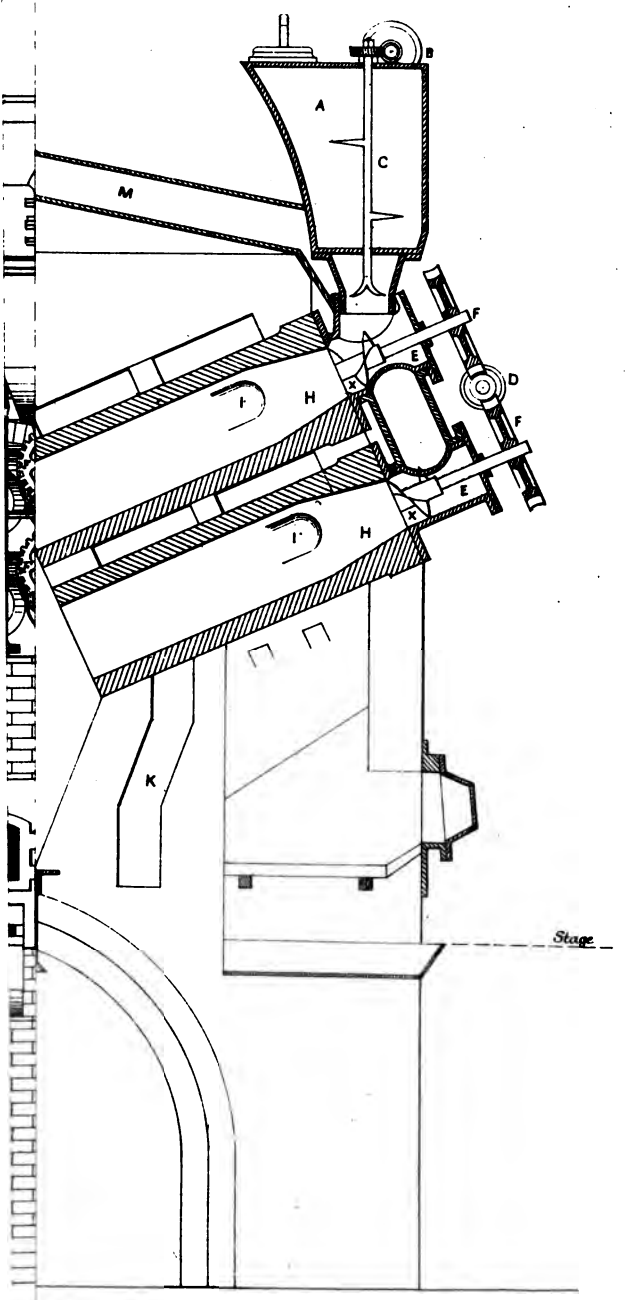
carbonization, and there were circumstances where such a system might be of inestimable value. It seemed that the coke produced from such a system would be of little value; but there might be places where coke was only of secondary importance, and the light evolved of great importance. So that the two systems, although diametrically opposite to each other, would have advantages which were well worthy of attention.

Mr. WEST (Maidstone) desired to thank Mr. Carpenter for the long time and attention he had given to this subject. He had spent a great deal of time in working out what he thought would be the most perfect system of carbonization, and he was not in a position to say it was not so, for though he was to some extent opposed to him, still he thought he was on the right tack. Whatever invention was brought forward, the most important work of a gas manager was that of carbonizing coal in the retort. Mr. Carpenter had spent a great deal of time and money on this matter, and anything he had said was worthy of great consideration. He referred to the pressure on the retorts, and that was a very important principle. In many London and large provincial works they worked with a vacuum, and he thought the right principle was to keep the pressure in the retorts as light as possible, say an eighth or a quarter of an inch. The question of retort-setting was no doubt an important one, and bore on the manufacture of retorts. Some men might have retorts which would not last half the time that they did with others. How was that? Because one might work with a vacuum and the other with pressure. If one worked under the least possible pressure he thereby not only got the volume of gas from the coal, but the full illuminating power. With regard to Mr. Carpenter's apparatus, the questions of cost and wear and tear would arise. No doubt the best retorts were often put into arches and destroyed in a short time, and the manufacturer was sometimes blamed, when in all probability he did not deserve it. He held that they should work under pressure, and see that the furnaces were properly kept up, and then no doubt, as a rule, they would get more gas and a higher illuminating power.

Mr. STEVENSON said he was pleased that the remarks which had been made were of a nature to widen the field and call for considerable attention. He desired to express his great pleasure at hearing of the new method brought forward by Mr. Carpenter, which he believed was a thoroughly good thing. It reminded him of the invention of Messrs. Porter and Lane, who proposed to carbonize coal in retorts by means of a screw. They set their retorts vertically, and experiments were made at the Horseferry Road station; but there they failed, because the screw, which was of cast iron, in several pieces, would not stand the heat. Apart from that, the principle was sound and the idea good. In Mr. Carpenter's arrangement that evil was remedied.

Mr. WILSON said a few years ago he patented an invention very much the same.

Mr. STEVENSON said with regard to his own paper, the first speaker referred to the seven retorts as not being so good an arrangement as the six, and as far as the combustion of fuel was concerned, and the dropping out of the retort, he quite agreed with him. For many reasons he preferred the setting of six, but his settings were arranged for seven before, and he thought his best plan was to do what he could with the seven. There was economy of space in this plan, and the middle retort did not in this system, to any appreciable extent, diminish the heat of the others. He had not attempted to introduce atmospheric air above the furnace doors to consume the carbonic oxide that might be formed, but relied entirely on the air spaces in the furnace, and he believed that no carbonic oxide left it unconsumed in any form. The draft was not great, and there was plenty of time for the gases to be converted into carbonic acid. With regard to the class of coal used, no doubt different coals gave different results; but he could not understand what Mr. Gore said about his setting not being able to carbonize Scotch coals. He was not acquainted with Scotch coals other than the Scotch cannels; but in ordinary settings they could carbonize cannels as well as ordinary coal, and it was continuously so used. His aim had been to get a higher heat, not to reduce it; for he did not think it possible to go to too high a heat, having regard to the



TRANSVERSE SECTION.

illuminating power of the gas. It might be a question whether it was desirable to use cannel to get a certain illuminating power; but the better and quicker it did it, the more economical it was. He used Silkstone coal, but he believed the setting would give equally good results with Newcastle. With regard to the pressure, he used an ordinary dip-pipe set to 1½ inches. He drew 1 inch vacuum, so that there was half an inch pressure in the retorts; and as the connections and main were of ample size, he did not think that the pressure was any more than that shown on the gauges.

Mr. Carpenter, in reply, said there was no opposition between him and Mr. West. If that gentleman would only employ a steam-engine to work his apparatus, instead of manual labour, no better system could be produced. He believed the apparatus he had described could be erected for £25 per mouthpiece from the foundation to the top. Of course, the elevator or lifting apparatus would do for a whole retort-house. With reference to Mr. Gore's remarks about a continuous pressure, so well experienced, as he was, he knew well the different systems, and it would be useless for him to expatiate with advantage on the saving of labour if they could be carried out. If the drawing and charging could be done away with, the saving in labour would be about 40 per cent. He had seen results from gas-works capable of making 60 to 70 million cubic feet per year, and he believed that his system, or one like it, whether carried out by himself or any one else, would be a great benefit to the gas manufacturer, simply because the work of the stoker was a degrading duty.

The President said they would all feel that Mr. Stevenson's paper was an admirable one, being an effort to bring into system, the observations of a careful observant man. If they could get something more in the shape of definite data to guide them in the apportionment of their apparatus throughout, it would be a very great help, and save every man watching and determining for himself the proportion of the different parts of gas-works. One object of the Association should be to bring together the observations of each man, so as to bring to something like system the apportionment of apparatus, and other matters of the same sort. As to Mr. Carpenter, of course he would simply say that it had nothing whatever to do with processes that might have been patented or invented in times gone by. He was perfectly sure that he had been labouring throughout on an idea which had occurred to him as an original idea, and the paper was eminently creditable to him.

HOW CAN GAS BE MADE POPULAR AS A FUEL FOR COOKING?

By Mr. S. Leoni (London).

I hope I shall not be thought guilty of presumption in placing this question before your meeting, my object being to raise a discussion which may result in the adoption of the best mode to benefit gas consumers as well as proprietors of gas-works, the interests of both being identical. The latter, no doubt, are sufficiently convinced that an increasing consumption of gas during the day, for cooking and other household purposes, would add to their sources of income. Consumers, however, require different inducements before adopting our suggestions, their objections to gas as a fuel being several, and some of them well founded.

1. Gas itself is comparatively in its youth. Some of you, no doubt, will remember the time when many of our towns were lit by oil, and we all know how conservative people are, especially the money-spending classes.
2. Those even who have tried the experiment of cooking by gas may have been disappointed as to the results.
3. Others, again, found the cost of a good gas kitchener too much for their means.
4. Some, however, who did not entertain these objections, were disappointed through the insufficiency of the gas supply when they most needed it.
5. The majority of consumers, being simply tenants and not owners of their houses, have naturally a strong dislike to lay out money on appliances, and especially fittings, which they consider should be provided by the landlord. They would, however, I believe, willingly hire a good kitchener in the same way as they now rent a gas-meter.

I will endeavour to place before you a few suggestions to overcome some of the objections referred to, and which I hope will meet with your approbation.

Gas being now comparatively cheap, and gas-stoves better than they were, some people (always in favour of progress) are already appreciating the advantages of gas as a fuel, and have thus prepared the ground for an increased movement in the same direction. The prejudice, therefore, is fast diminishing; the real objection is the one of the majority who, as tenants, would be willing to pay £1 or £2 a quarter for gas for cooking, in addition to their present outlay for lights, considering such an amount reasonable in lieu of a coal bill, or part of it, the saving of firewood, the absence of dirt, smoke, soot, &c., and the economy of labour, especially during the summer; but these tenants cannot afford to buy a kitchener, or do not care to do so. Gas proprietors, or corporations owning gas-works have, therefore, the remedy in their own hands, by providing kitcheners at reasonable rental, and by maintaining a good average pressure during the daytime.

I should like to see proprietors follow the example already set by such pioneers as the Crystal Palace District, the Maidstone, Hastings, and other Companies and Corporations, and who, I understand, are satisfied with the results of what they have initiated, and for which great credit is due to them.

A good substantial kitchener, fit to do all the work in an 8 or 10-roomed house, or to be used as an accessory in a larger establishment, may be hired out advantageously at the low rent of about 2s. 6d. per quarter.

Besides boiling, stewing, frying, &c., the kitchener should roast and bake to perfection at a reasonable expenditure of gas; it must be simple in construction, and stand wear and tear for years without getting out of order; must also be easily cleaned, and be capable, when required, of being sent out fresh and ready from one consumer to another. The oven should be lined with heat reflector tiles made of fire-clay or other non-conducting material, and should be fitted with atmospheric gas; the required temperature is then readily obtained with a consumption of about 20 cubic feet per hour, and can be maintained with less.

The inside lining being, as described, a bad conductor of heat, there is scarcely any waste of calorific power, and the heat is uniform, which is a great desideratum for roasting and baking. The joints of meat when cooked have very much the same appearance as those done before an open fire; but they lose rather less in weight, are plump and full of gravy, they require neither turning nor basting, and can be left without any attention whatever during the time required for roasting, which is regulated according to the weight. The kitchener, as described, may be used with great advantage by a family of from six to twelve persons, and, with a little manipulation, will turn out a capital dinner for twenty.

It is, however, important that the kitchener should not offer too many facilities, which may result in big gas bill, as I find, in practice, the production of hot water by gas to be the most extravagant feature in a kitchen. Whether a self-feeding boiler or one fed by hand is used, or one forming the jacket of the oven either at the top or sides or back, the waste of gas is generally the same—servants, and sometimes even the mistress herself, will keep the gas burning all day, and allow the water to steam away.

Whilst the daily meals for a middle-class family can be cooked with from 80 to 100 cubic feet of gas, the hot water will require quite as large an expenditure if a boiler is in use. The only remedy against such extravagance is to make servants fill kettles or pans with water, and set them to boil over the burners of the hot-plate. The trouble of filling such utensils, and the exposed position of the burners under them, have the desired effect in causing the gas to be at once turned off when the water has boiled. A boiler has also the disadvantage of furring inside and coating with soot outside; so that the heat has to penetrate through both of these deposits, at a considerable waste of power. From the same causes the boiler is subject to constant damages, and will require repairs from time to time.

The following is an average consumption for the daily meals for a family of eight persons:—

Breakfast—	
Consisting of tea or coffee, ham and eggs, or chops, and also toast, including hot water for washing up	20 cubic feet.
Dinner—	
Six-pound joint and pie	30 ,,
Soup, fish, vegetables, potatoes.	20 ,,
Hot water for washing up.	10 ,,
Ditto for tea, &c.	10 ,,
Total	90 cubic feet.

Another consideration which can scarcely be too much appreciated by the consumers, is the independence they gain with reference to their cooks and servants in general by the adoption of gas-stoves, which enable ladies and their children to do their own work with the greatest of ease, and, in many cases known to me, the services of a cook are dispensed with altogether.

As to the consumption, I will quote here from my own gas bills paid to the Brentford Gas Company. My family is six in number, with the addition of occasional visitors to dinner, &c. No coals are used in the kitchen, and therefore all the cooking and the supply of hot water, including three or four baths per week, has to be provided by gas. The last four quarters

(at the rate of 4s. per 1000 cubic feet) amounted to £4 9s. 8d. for the kitchener and bath boiler, and £4 13s. 3d. for the lights. Taking this to be a fair average, the rental for 1000 householders would amount to £4483 6s. 8d. for the kitchen per year, and £4662 10s. for lights, representing, therefore, an increase of nearly 50 per cent. due to the additional use of gas for fuel.

With such a result before them, proprietors of gas-works have every interest to induce consumers to use gas as fuel, by inviting them to hire the necessary appliances, or to purchase them by instalments. We must, however, not overlook the important question of pressure, which should not be less than 8-10ths of an inch close to the meter, especially in large establishments where one meal has to be cooked for 500, 1000, or more persons.

Gas kitcheners are now constantly used in many of the national schools of cookery, and the teachers recommend them to the ladies attending their classes.

A step in the right direction to overcome inveterate prejudices would be the organization of periodical exhibitions, where the public would have the opportunity of hearing practical lectures on the subject, accompanied by ocular demonstration. Such an exhibition has just been held, with great success, in the Town Hall of Birmingham, initiated and carried out by the Birmingham Corporation Gas Committee.

With your permission, I will now explain the working of a few small new appliances, adapted for offices, workshops, artizans families, and also for the use of ladies—my object being to show you what can be done with 10, 20, and 30 cubic feet of gas.

The smallest quantity (10 feet) will roast 2 lbs. of meat and steam 4 lbs. of potatoes. With 20 cubic feet, we can roast 4 lbs. of meat and steam 8 lbs. of potatoes. Again, with 30 cubic feet, we can roast 4 lbs. of meat, steam 8 lbs. of potatoes, also a pudding, boil vegetables, and supply one gallon of hot water for washing up; and also one quart of boiling water for tea. This is sufficient for an artizan's family. The cooker, intended for a lady's special use, will roast 4 lbs. of meat, bake two pies, steam 5 lbs. of potatoes, and supply 3 gallons of boiling water for washing up; the whole with 30 cubic feet of gas, in two hours time. With an additional consumption of 10 cubic feet of gas, the hot-plate can be used for soup, fish, or *entrées;* in fact, this kitchener is sufficient to cook a dinner for eight persons.

I avail myself of this opportunity to mention a few facts known to me through personal experience, with reference to cooking by gas on a large scale, and where the advantages are so great and manifold that the difficulties of prejudice and even expense have been considerably reduced.

At the London Hospital they cook daily for 800 inmates, at an expense of 7s. for gas; three persons only being employed to do the cooking and kitchen work. Their apparatus has now been in use for eight years, has only been repaired once, and this after seven years of constant work. From a register carefully kept during the whole of this period, the authorities are enabled to certify that the waste in meat has been materially reduced by this system. In short, they save over £500 a year in meat alone, not taking into consideration the other advantages.

At Mr. Whiteley's, Westbourne Grove, 600 to 700 lbs. of meat are roasted daily, at an expense of 5s. 3d.; and 200 gallons of water are boiled for tea at a cost of 10d. Many of the best-known hospitals, infirmaries, unions, and asylums now use gas for cooking, and amongst these are Guy's, Lambeth, St. Saviour's, Poplar, and Stepney, with a total of above 3000 inmates. Doubtless a number of other similar places known to members of this Association have also adopted gas for cooking purposes. Messrs. Bertram and Roberts, Spiers and Pond, and other large refreshment contractors, also large hotels and West-end clubs, use gas in preference to other fuel, because they find it more efficient and cheaper than coals, to say nothing of the economy of time and labour. Large warehouses here, in town and in the country, are also using gas, and the same may be said of many public schools. I could even mention some private establishments, the owners of which spend princely incomes, and who use gas for cooking in preference to other fuel.

I have avoided the subject of heating apartments by gas, for the simple

reason that it cannot be done so effectively and cheaply by this means as by coals. A good coal fire is more cheerful and comfortable than any gas fire, and, in a fire-grate properly constructed, does all the required ventilation. If coals are superseded by an asbestos fire, the expense would be quite double as much, without obtaining such good results. There are many instance where a small gas fire or calorifere are preferable, sometimes for want of a fire-place, and sometimes when the warming is only needed for a few hours during the day. In such cases the consumer will find out for himself the most suitable stove, and therefore he had better be left to his own resources.

In conclusion, I am happy in feeling that the facts and figures proving the great importance of the subject, and the general information I have been allowed to put before this meeting, will justify and induce managers to use their influence with their proprietors to take into consideration the steps I have suggested to make popular and promote the use of gas as a fuel for cooking.

The PRESIDENT said he very much regretted that time did not allow of giving this practical paper the discussion they would like.

GENERAL BUSINESS.

Election of Honorary Members.

The President then proposed that the Association should elect as Honorary Members the President and Past Presidents of the Société Technique de l'Industrie du Gaz en France. This, he said, would only be reciprocating a courtesy which their sister Society in France had already paid them, and the Committee, therefore, unanimously recommended that they should be elected.

This was unanimously agreed to.

The President said they were very glad to welcome amongst them at that meeting three members of the profession from the other side of the Atlantic. He understood, from gentlemen who had visited America, that they were received by their brethren there with the greatest kindness, and every effort to make their visit pleasant and profitable. He had, therefore, to propose, as an expression of the pleasure they felt in seeing these gentlemen amongst them, that they should elect Captain G. Warren Dresser, the Editor of the *American Gaslight Journal*, who had long occupied a prominent position amongst gas men in America, as an Honorary Member of the Association.

The resolution having been carried unanimously,

Captain Dresser said this honour was entirely unexpected, and he could not take it as addressed to himself in the slightest degree. He understood that the spirit in which it was given was not in honour of him as an individual, but his countrymen. Some of them had come over to see if they could learn something in the mother country, and they would be extremely delighted to go back and tell their brethren with what kindness, honour, and distinction they had been received.

Election of Committee and Officers.

The Secretary read the report of the Scrutineers as to the result of their examination of the ballot papers, from which it appeared that the following gentlemen had been elected for the ensuing year:—

President.—Mr. W. J. Warner.
Vice-Presidents.—Mr. J. Douglas, Mr. C. Hunt, and Mr. G. W. Stevenson.
Treasurer.—Mr. H. Newall.
Secretary.—Mr. W. H. Bennett.
Committee (new members to replace those going off by rotation).—Mr. J. Braddock, Mr. W. Carr, and Mr. R. H. Jones.
Finance Committee.—Mr. G. Livesey, Mr. J. Eldridge, Mr. G. W. Stevenson.
Auditors.—Mr. A. Hersee and Mr. A. Lass.

Report of Committee.

The Secretary read the following report:—

"Obedient to the instruction of the last general meeting, your Committee have considered the proposition made by Mr. Travers—that the bounds of the Association should be enlarged so as to admit Water Engineers to membership.

"Your Committee fully recognize the fact that to a certain number of the Members, who associate the duties of Gas and Water Managers, there would be an advantage in the change proposed, and that to such, papers and discussions on water-works topics would be interesting and profitable. They feel, however, on the other hand, that the change proposed would be a radical alteration in the character of the Association, which circumstances do not call for, and which, in its effect, is more likely to produce embarrassment than advantage. Desirable as it may be to add to the number of our members, it is of still more consequence that the proceedings of the meetings should interest and help those who attend them. Your Committee are of opinion that the consideration of gas matters would not prove attractive to gentlemen whose business was confined to water-works, and *vice versâ*. A consequence would probably be that members would, to a greater extent than at present, absent themselves during a portion of the proceedings. Your Committee are, therefore, of opinion that it would not be beneficial to the Association to make the alteration proposed.

"Your Committee desire to call the attention of members to two other matters—

"*The Financial Position of our Association.*

"On this point they cannot do better than adopt, as their own, the following passage from a report to them of the Finance Committee, dated March 28, 1878, which is as follows:—'Your Committee have given their attention to the financial state of the Association, and they find that the recommendation contained in their report of last year, that the members should be informed that a slight increase in the subscriptions was necessary, in order to make the income superior to the expenditure, has met their expectations, and that there is a balance of about £15, on the year 1877, in favour of the Association. Although your Committee do not consider it desirable that there should be any considerable annual increase in the balance carried forward, they are of opinion that provision should be made to prevent occasional deficits in future. Your Committee recommend that, in future, arrears of subscriptions should appear in the accounts of the year as an asset, and that subscriptions remaining unpaid at the end of the second year should be written off. In order to reduce the arrears as much as possible, your Committee recommend that the Secretary be instructed not to forward the copy of the transactions to any member until his subscription for the current year has been paid. The accounts will then be so clear and simple that it will be impossible to deduce erroneous conclusions from them.'

"Your Committee, not prepared to advise the abolition of premiums, have decided to add to these recommendations of the Finance Committee this further one—that the subscription of all members elected in future be fixed at a guinea, and not left optional, as at present.

"The second matter which has engaged the Committee's attention, and on which they now report, is

"*The Nomination of Members of the Committee.*

"This was the subject of some discussion at the Bristol Meeting, ending in a resolution confirming the present rule. Your Committee felt, however, that although it was very undesirable to make alterations in the rules at a general meeting without notice, and where it was impossible to spare sufficient time for the proper consideration of the proposal made, yet it was their duty to give attention to any suggestion made at the meeting.

"The Committee have had the advantage of suggestions from several members since the discussion took place, and they now submit the following plan for consideration, which has been designed to meet the views of those members who think the Committee are not sufficiently representative of the whole body:—

"'It shall be open to any member to propose another as a member of Committee. If the proposal is duly made, and supported by the names of two other members, and sent to the Secretary on or before the 31st of March preceding the annual meeting, the Committee shall accept the nomination, and include the name of the gentleman so proposed in the

voting list. No member shall propose or support the nomination of more than one member of Committee in the same year.

"'Further, the number of names to be nominated by the Committee shall be reduced from twelve, as at present, to six; but in the event of there not being six names nominated by other members, the Committee shall fill up the number to twelve, as required by the rule. The Committee recommend that Rule 30 be altered in accordance with this suggestion.'"

The PRESIDENT moved that the report be received, which having been carried, he invited discussion upon it. He said if there were no remarks to be made upon it, he would ask some member of the Committee to move its adoption. He might say, however, that the Committee had looked very carefully into the matter, and they felt that the suggestions made at the last meeting had considerable force in them, that the election of members of the Committee should be made as fully representative as possible, and that therefore it was advisable to widen the constituency proposing them in this way. Now that the rule was proposed to be altered, he could only express his hope that members would avail themselves of it, and that it would not be left to the Committee to nominate the whole number, though he should not be much surprised if such proved to be the case.

Mr. WEST (Maidstone) moved the adoption of the report.

Mr. HEPWORTH (Carlisle) seconded it.

Mr. CARR (Halifax) said there was a remark in the report to which he objected—namely, where it stated it was hoped it would meet the views of gentlemen who did not think the Committee were sufficiently representative. He, himself, did not know who were the people who held that opinion; and he was present during the whole of the discussion twelve months ago, and took part in it, and he did not remember any one making the charge that the Committee were not sufficiently representative. The only objection taken to the rule was that the nomination placed the Committee in rather an unfortunate position, and it was with a view to remove the possibility of any members saying that they were not represented by the Committee that this was proposed. He was much pleased that the Committee had taken the matter in hand and dealt with it in the way they had. He believed they had given the matter their best consideration; and the plan they proposed was, no doubt, the best, under the circumstances. They had shown, not only their representative character, but their desire to push the best interests of the Association, and he believed now it would be utterly impossible for any section of the Association to say they were unfairly represented. They must always go by the majority of members, and they would have the opportunity of trying their strength at any time they felt disposed.

Mr. STONE (Weymouth) said one part of the report seemed rather hard—namely, that which would compel new members to subscribe one guinea. He feared this would deter many managers of small gas-works from joining, because it would be a great burden to many men in such a position, who were really those most requiring the privileges of the Association. There were a great many members of the Association at present who would not feel it a hardship to subscribe one guinea, if necessary; but many did not think it necessary to do so at all. The expenditure of the Association had for several years been increasing to what some thought an alarming extent. Many years ago the funds of the Association improved until they got to something like £400 in hand, but for two or three years past they had been gradually diminishing. Thus it happened, unfortunately, that the richer they got the poorer they were. The question was whether they should meet that position by increasing the subscriptions or diminishing the expenditure, and he should rather advocate the latter.

The PRESIDENT said, as the remarks of the last speaker seemed to be received with favour by the meeting, he should be glad if those who were of the same opinion would express it.

Mr. JONES (Chesterfield) said he took part in this discussion somewhat reluctantly. He thought that the change shadowed forth in the report now presented was of such serious importance that they ought to have more time for its consideration. With reference to the introduction of Managers

of water-works, he regretted that the Committee could not see their way to advise the Association to try the experiment. Representing as he did a Water and Gas Company with a capital of £300,000, he did not think his position as a Gas Manager was at all disparaged by being associated with the Water Department. He should like to see their brethren in the water line associated with themselves, as there were many points in common which might be dealt with by the Association to the advantage of both Water and Gas Engineers. The point, however, to which he wished more particularly to allude was the rate of subscription, and he agreed with his friend, Mr. Stone, that it was highly desirable for that portion of the report to be re-considered. In times like the present, they could not expect men who were managing small gas-works to be throwing away a guinea for one meeting a year, and there were many things in which the expenses might be curtailed. For instance, he found the secretarial expenses of the North of England Institution of Mining and Mechanical Engineers averaged 21½ per cent. of the income, and they had five meetings a year. The Chesterfield and Derbyshire Institute of Engineers, of which he had the honour to be a Councillor, averaged a smaller per centage for secretarial expenses, and they had five meetings a year, and their transactions were most elaborately got up. The Secretary of this Association, however, received more than 36 per cent. of the income, for one meeting a year. He was quite satisfied that the Finance Committee could see their way, if they would, to diminish the expenditure, instead of raising the subscription. They were paying the Secretary excessively, and most excessively for office rent. The office rent was £40 a year. The Secretary £140, and there was a further charge of £9 8s. 9d. for travelling expenses of the Committee. Time was when the gentlemen who served on the Committee were content to sacrifice their time.

The PRESIDENT, interposing, remarked that, while he hoped all members who wished would express their opinion on this point, he must ask them to bear in mind the lateness of the hour, and the short time in which they had to get through the business.

Mr. JONES said he regretted exceedingly, as he was in order in discussing the financial position of the Association, that he was not allowed to proceed.

The PRESIDENT said he had not the least desire to ask Mr. Jones to conclude his remarks at once; he only wished to point out to him that he had already occupied a considerable time.

Mr. THORNELOE suggested that it would be as well for the Secretary to retire while this discusion took place.

[The Secretary expressed his perfect willingness to do so. The members generally, however, expressed dissent.]

Mr. JONES said he did not wish to take up time unnecessarily, and he would, therefore, simply move that the report, as presented, be ordered to lie on the table, so that members might have time to consider it.

Mr. MEAD (Sutton) was anxious the members of the Association should always continue to act as harmoniously together as they had in times past. It might be in the recollection of Mr. Jones and others, that the Secretary's salary had been increased by themselves without any application from him; and, under those circumstances, it would be most ungracious now to find fault with the amount he received. That they had an excellent Secretary, no one could doubt, nor that they would have great difficulty in finding another who could do the same work so well as he had done it. He (Mr. Mead) trusted, therefore, that, whatever their opinion might be, they would not think of withdrawing any part of the salary they themselves had voted. As to the question of subscription, he could not conceive that any Gas Manager could consider that 21s. a year was too much to pay for the privilege of attending these meetings. He had had a great many years experience of gas matters, but he had never attended a meeting without going away the better for it.

Mr. BARRATT (Grantham) said he knew there was a wide dissatisfaction on the part of many members as to the financial position of the Association, and the manner in which the business had been conducted. He, therefore, had great pleasure in seconding Mr. Jones's amendment, in

order that the question might be properly ventilated. He was not satisfied with their financial position, and thought that the expenditure was considerably more than it ought to be. It would be a serious infliction on many good men who wished to join the Association if the subscription were raised as proposed. There were no men better able to judge what a man was worth than Gas Engineers; for it was part of their constant duty to calculate minutely the expenditure in every department, and if there were any excess anywhere, to put their finger upon it and have it altered. He hoped, therefore, the subject would be discussed calmly and dispassionately; but he could not help saying that he was not satisfied with the manner in which the secretarial duties were performed.

Mr. GEORGE LIVESEY thought the discussion was taking a course which would be anything but beneficial to the Association, as it seemed becoming a personal question. He would also point out that there were many other matters in the report besides the one to which attention was now drawn, and which it was important should be settled, and settled at once. Then he would also ask, in reference to the Secretary, whether the members, any of them, were in a position to know what the duties performed by that officer were. One only knew what a man was worth when one knew what he did. Having himself been connected with the Association officially for something like ten years, and having, perhaps, seen as much of the work done by the Secretary as any one, he considered the salary received was anything but too large. They had in Mr. Bennett a man who devoted himself heartily to the interests of the Association, who was always thinking how he could best promote those interests, and to bring up this question in the way it had been done, after Mr. Bennett had served the Association well all these years, was anything but praiseworthy on the part of any members. Nor was there any necessity for it. The whole question had arisen upon the subject of raising the subscription from a half to one guinea. As a member of the Finance Committee, he fully accepted the responsibility of that recommendation, but he did not insist that it was essential to the prosperity of the Association. He had gone into the accounts carefully, and he found that, with the exception of one single year, the expenditure had always been less than the income. The accounts had certainly been published in a form which did not clearly express the exact position of the Association; and the Finance Committee, in order to avoid arrears in the future, made the recommendation in the report. Last year the income was about £30 above the expenditure. It was not necessary, therefore, to increase the subscription, though he thought it was advisable. He thought 10s. 6d. was too low; and, besides, he thought the subscription ought to be paid by the Companies or Corporations, and that, if the matter were properly brought before them, they would do so. The point before the meeting was, therefore, whether they should have an increased subscription for future members. The existing members would go on paying the same, if they chose, and there would be no pressure put upon them to pay more. He thought this matter might be put to the vote, and then the other points in the report could be taken on their merits. As to reducing the Secretary's salary, he was quite certain the members generally would not listen to it for a moment.

The PRESIDENT asked if Mr. Jones would be willing to withdraw his amendment in order to put the question suggested by Mr. Livesey.

Mr. JONES had no objection personally to the course suggested, but he should like to take the opinion of his brethren before consenting.

The PRESIDENT said he could not allow another speech.

Mr. JONES said in that case he must decline to withdraw the amendment.

Mr. SMITH (Darlington) thought that, according to Mr. Livesey's own view, there was no necessity for raising the subscription, for it appeared that in every year but one their assets had been in excess of the liabilities. If, as Mr. Livesey suggested, Gas Companies or Corporations paid the subscriptions for their Managers, it would be then time enough to increase the subscription; but until such was the case he thought the Committee had scarcely any ground for making such a recommendation.

The PRESIDENT said he should have preferred to put the report paragraph by paragraph, but as Mr. Jones's amendment was not withdrawn he was obliged to put it.

Mr. IRONS (Gosport) suggested that the mover of the original resolution should consent to its being altered so far as regarded the paragraph referring to the subscription. They ought to consider the persons who formed the Association, and who fixed the rate of subscription at 10s. 6d. In early times they were much indebted to two eminent men, the late Mr. Barlow and Mr. Hawksley. He remembered Mr. Hawksley being in the chair as President when a similar question was brought forward, and he strongly advised that while the subscription might be increased to one guinea for those who were willing to pay it, it ought not to be increased compulsorily. The objection that many felt to the paragraph in the report was that it would make an increase compulsory for future members, and as there was no real necessity, he asked the Committee to withdraw that part, so that the meeting might adopt the rest, which was very serviceable.

The PRESIDENT entirely agreed with Mr. Irons's remarks, but he had no option but to put the amendment.

The amendment was then put, and lost by a large majority.

Mr. GEORGE LIVESEY proposed another amendment, to the effect that the paragraph relating to the increase of subscriptions be expunged.

Mr. CARR seconded this amendment, which, on being put to the meeting, was carried almost unanimously.

The PRESIDENT, in putting the original motion, with the paragraph relating to increased rate of subscription expunged, said it would be hardly necessary to discuss it further, after what had taken place; but he would remind the members that it was the outcome largely of the discussion which took place at the Bristol meeting, where it was argued that it was impossible to discuss the proposal then made, and it was therefore negatived. The Committee, however, felt it their duty carefully to consider whether the meeting had been acting rightly in negativing the proposal, and in the interval they had most carefully considered the suggestions made. The members need not be under any apprehension, therefore, that, in adopting the report, they were doing things hastily or inconsiderately.

The motion was put, and carried *nem. con.*

MEMBERS IN ARREARS.

The SECRETARY then read the list of those whose subscriptions having been in arrear for two years, had *ipso facto* ceased to be members.

TIME AND PLACE OF NEXT MEETING.

The PRESIDENT said the next business was to choose a place of meeting for next year.

Glasgow, Newcastle-on-Tyne, Portsmouth, and Sheffield were all proposed by various gentlemen, but Portsmouth was afterwards withdrawn. During the conversation which took place,

Mr. HUNTER (Salford) suggested that in future it would be well if some formal invitation was sent up from provincial towns, because it was very easy for gentlemen to get up and propose a certain place of meeting, without having taken any means to ascertain whether a visit would be locally acceptable.

Mr. HEPWORTH (Carlisle) said the North of England Association had considered this matter, and, though they had not sent a formal application, they were unanimously of opinion that it would be the greatest pleasure the Association could confer upon them if they would meet next year in Newcastle-on-Tyne.

On a vote being taken, the meeting decided by a very large majority in favour of Newcastle.

The President then moved a cordial vote of thanks to the gentlemen who had contributed papers. He said he was hardly in a position to express a fair opinion as to the character of this meeting, as compared with others; but, personally, he thought it had been very successful, for he felt sure that a better set of papers they had never had. The attention with which they had been listened to, and the large attendance while they were being read, had been the best testimony as to their character. He would, of course, include in the vote those gentlemen who had prepared papers which, for want of time, had not been read.

The resolution was put, and carried unanimously.

Mr. Warner said he felt very deeply the high honour conferred upon him in electing him as President for the coming year, and he was quite sure that the people in Newcastle-on-Tyne would equally feel it their duty, as he felt it his, to advance the interests of the Association, and to maintain its high honour.

Mr. Ohren moved a vote of thanks to the Committee for the manner in which they had carried out their duties during the past year, and for the report which had been adopted.

The motion was carried unanimously.

Mr. Henry Woodall moved a vote of thanks to the Treasurer, Mr. Newall, whose operations, he said, reminded him of the laws of nature; they were always constant, though never seen.

The resolution having been carried unanimously,

Mr. Storer moved a vote of thanks to the Scrutineers, Mr. Hartley and Mr. Darwin.

This resolution was also carried unanimously.

Mr. Hepworth moved a vote of thanks to the Society of Arts, whose hospitality they had always experienced when coming to London, and to Mr. Le Neve Foster, the Secretary. He never came to that room without thinking also of the indirect aid which the Society of Arts had given to their Association, by the publication of some very valuable lectures on subjects connected with their operations.

The resolution was carried unanimously.

Mr. George Livesey said he was called upon to perform an act of justice, which the Society had for some time neglected. In former years the Association were accustomed to pass a vote of thanks to the late Mr. Barlow for taking notes of the meeting, and furnishing them to the Society, thus contributing very largely to their income, and diminishing their expenses. That kindness had been continued by his successor, Mr. King; and he hoped Mr. King would not feel it had been a slight on the part of the Association that they had never acknowledged his kindness. It had been generally understood by the members that Mr. King had done this voluntarily and generously, though, somehow or other, they had omitted to pay a formal acknowledgment of the services thus rendered. It was their bounden duty to express their hearty thanks to Mr. King for his great generosity, without which the Association would have found before this that the half-guinea subscription was insufficient to meet their expenses.

The President, in putting the motion, said as there had been an omission before, he hoped the members would, if possible throw the fervour of half-a-dozen years into the vote of one. They all felt such personal regard and friendship for Mr. King, and such an interest in the work he was doing, that it was always very pleasant to them to see him among them.

The resolution having been carried unanimously,

Mr. King acknowledged the vote, and thanked the meeting for the very cordial manner in which it had been adopted. His predecessor in the conduct of the Journal, the late Mr. Barlow, had always manifested great interest in the prosperity of the Association, and he had himself been influenced by the same spirit. It had been his happiness to attend every meeting of the Association since the first gathering in Manchester, in 1863, and he had personally reported the proceedings each year until now that the state of his health prevented him from undertaking the labour.

He was glad, however, to be present on this occasion, and, with the aid of his friend at his side, to continue his work. Any assistance he had rendered to the Association had been rendered with much satisfaction to himself.

Mr. MORTON proposed a vote of thanks to the President. He wished some one better fitted to speak of him had been chosen, although no one knew better than he the high qualities of Mr. Corbet Woodall. He had been intimately associated with him throughout his professional career, and had seen with much pleasure the progress he had made therein. He therefore proposed a cordial vote of thanks to Mr. Woodall for his conduct in the chair, for the onerous work he had done for the Association during the year, and especially during the past month, and for the admirable Address with which he opened the meeting.

The resolution having been carried by acclamation,

The PRESIDENT thanked the meeting for the kindness with which they had received Mr. Morton's remarks. He could only say there were few things more satisfactory than to hear, as he had heard, for the first time, that Mr. Morton's acquaintance with him for a term of years had not diminished the regard with which it commenced. He could only say, with reference to the proceedings of the last two days, that they had been to him a source of continued satisfaction and pleasure. He commenced his duties with considerable misgivings, but his apprehensions vanished almost from the first moment of taking the chair, and the confidence he experienced in the cordial support he should receive from the members had been more than fully realized. Before sitting down, he wished to propose a vote of thanks to the Secretary. He was particularly glad of the opportunity of being able to say a word or two with reference to that gentleman. He had no idea, until the commencement of his year of office, what the amount of attention and labour was that devolved on the Secretary of the Association. He could assure the meeting most emphatically, that if those duties were rendered in return for the emolument received, he should regard the remuneration given as utterly inadequate to the services performed. Furthermore, he did not believe that those services were rendered for the sake of the emolument but they were done by Mr. Bennett with a hearty and loving service, which was of great value to the Association.

The resolution having been carried unanimously,

The SECRETARY briefly and appropriately thanked the members for their kindness.

This being the whole of the general business, the meeting was brought to a close.

THURSDAY, JUNE 20.

At eleven o'clock this morning the members assembled at the Phœnix Gas Company's gasholder-station in Kennington Lane, to witness the progress made in the construction of the largest gasholder at present in existence. Here they were met by Mr. Shand, the Deputy-Chairman of the Company, from whom they received a very hearty welcome, which was cordially acknowledged on their behalf by Mr. Warner, the President of the Association for the coming year. Mr. Woodall, the Engineer of the Company and present President, furnished the visitors with every desired information respecting his large and important work. After spending two hours at the works, partly in doing justice to a choice refection provided for them by the Phœnix Gas Company, the members proceeded to the Vauxhall station of the South-Western Railway, whence they were conveyed to Hampton by train. Here an inspection of the works of the Grand Junction and Southwark and Vauxhall Water Companies reservoirs, engines, &c., took place, and an adjournment to Bushey Park followed, where, after partaking of an elegantly-appointed luncheon, the remainder of the day was spent in viewing the Great Hall, Picture Galleries, and grounds of Hampton Court Palace, the company returning to London about eight o'clock in the evening.

On Friday, June 21, those of the members who intended to visit the Paris Exhibition started from the Victoria Railway Station at 7·40 a.m. for Dover, whence they proceeded, *vid* Calais, for the French capital.

We have been favoured by correspondents with narratives of the engagements of the following days.

On Saturday morning, at ten o'clock, the members visited the Exhibition, where they were met by MM. Arson, Servier, Ellissen, and several other gentlemen, in the Pavillon de la Compagnie Parisienne du Gaz, who explained to them the interesting exhibits of that Company, including elaborate models and drawings of their apparatus, drawings of the brick-works and tar and ammonia plant, samples of products, stoves for cooking by gas and coke, gas-engines, main-pipes, and the method of attaching services, &c. This visit was altogether of great interest, and the members were much impressed by the thoroughness with which the Paris Gas Company had carried out their exhibition.

In the evening, by the invitation of M. Denayrouze, through Mr. Woodall, about 100 of the party assembled at the works of the Electric Light Company, in the Avenue de Villars, and received from M. Jablochkoff and his assistants a very interesting explanation of the apparatus employed in electric lighting as now used in Paris. Afterwards, by the courtesy of the Electric Light Company, the whole party was invited to the concert in the Orangery of the Tuileries Gardens, where they saw the orchestra and grounds illuminated by 48 electric lamps.

On Monday the Paris Gas Company received the members of the British Association at their works at La Villette. Every care was taken by the officers of the Company to explain what was new or strange to the visitors, and the latter expressed very generally admiration of the care taken by the Company to utilize every source of profit open to them. The tar, ammonia, brick retort, and patent fuel works were all in turn examined, and note-books were in constant requisition. After this inspection the Members of the British Association drove to the gas-works at Ivry, where they were met by the Members of the Société Technique de l'Industrie du Gaz en France. A beautiful luncheon had been provided by the Paris Gas Company for the whole party, numbering about 250, in one of the retort-houses, which had been very prettily decorated for the purpose. After the luncheon, and a hearty acknowledgment of the Company's kindness, an inspection of the Siemens furnaces in use for heating the retorts concluded the visit. In the evening a banquet was held by the Société Technique, on the island of the Great Lake in the Bois de Boulogne, to which the President and Committee of the Association were invited. About 60 ordinary members also joined the party. The proceedings of this evening will long remain in the recollection of those who took part in them. The lovely scenery, charming music, and hearty welcome were alike fully appreciated. The health of the British people, and especially the Association of Gas Managers, was cordially drunk, and the reply of the President (Mr. Woodall) was received with hearty applause. The toast of the Société Technique and the French people was proposed by Mr. Woodall in terms which secured enthusiastic concurrence, and the most delightful concord prevailed throughout.

The proceedings of the Société Technique on Tuesday were attended by a large number of the English visitors, who took some part in the discussions carried on.

On Thursday morning a large proportion of the party returned to London, but many remained to see the National Fête on the Sunday following. All alike heartily expressed their satisfaction with the visit, and the arrangements made for their reception and entertainment.

APPENDIX.

The following paper presented to the Meeting of the Association was, for want of time, taken as read, and was ordered to be entered on the "Transactions:"—

THE PURIFICATION OF COAL GAS WITH ANHYDROUS OXIDE OF IRON.

By GEORGE E. DAVIS, F.I.C., F.C.S., &c.

In 1871, when connected with the alkali trade, I went through a series of experiments, with a view to utilize sulphuretted hydrogen, and found that anhydrous oxide of iron absorbed this gas with avidity, even when very dilute, and I had no difficuly in producing a material containing 60 per cent. of sulphur, by frequent saturations and revivifications; and the next year, when I was more intimately connected with the manufacture of gas-purifying material, I received with some doubt the assertion that peroxide of iron in the anhydrous state would not purify gas.

This assertion is still clung to by some, not argued upon, and the anhydrous oxide has not been practically tried by many, yet the notion is so widely spread that the mere mention of such a thing being possible is immediately classed as an absurdity.

The above experiments were then forgotten completely until 1875, when I chanced to hear that one Gas Manager was using an anhydrous oxide for the purification of his gas. Not having asked for permission to mention the works where this took place, I consider I am not justified in mentioning them; but I have no doubt that if the Manager of those works is present he will give you some account of the working of that oxide.

I must confess that until I had both seen and analyzed the spent oxide in question, I was a little dubious as to the result; for, in the first place, I did not think there was a Gas Manager who had the temerity to charge his purifiers with oxide of iron (anhydrous); and, secondly, if the assertion often made to me was correct, that, although anhydrous oxide would take up sulphuretted hydrogen when mixed with air, and not very dilute, yet it would not take up sulphuretted hydrogen from coal gas; the resulting spent oxide could only be of very small value to the chemical manufacturer.

The oxide of iron used was what was known as "blue billy," the residue, in fact, from copper pyrites, after the sulphur had been eliminated by combustion, and the copper extracted by furnacing with salt.

This oxide, or "blue billy," is not so suitable as most other oxides for gas purification; it lies very close and is very heavy; moreover, it is not finely ground, so that the coarser particles are not so active as the finer, in the proportionate weight of iron which they represent. Levigated and mixed with a large quantity of sawdust, it would act better; but still, in its natural state, when used at the works before mentioned, it became saturated and unfit for further use when it contained 36 per cent. of sulphur. This was, I consider, very satisfactory, as "blue billy" contains on an average 24 per cent. of particles so coarse that they will not pass through a sieve with eight holes to the inch, and only about 55 per cent. will pass through a sieve having 12 holes to the inch.

When thrown out of use the oxide contained as follows:—

Moisture	16·40
Tarry matters	1·00
Sulphur	34·00
Ferric hydrate	6·28
Ammonium sulphocyanide	1·56
Ammonium chloride	0·72
Insoluble in dilute HCl	35·50
Sawdust, &c.	4·54
	100·00

My opinion is that this could have been worked until it contained 50 per cent. of sulphur, for reasons which I shall give farther on.

This result led me to try the purification of gas by means of a finer quality of anhydrous peroxide of iron; but getting this tried was by no means an easy matter. I could not find any Gas Manager who would try such an oxide, even if the said oxide were given him, so I had to wait until I could find some one of my own way of thinking.

This was eventually done, and the oxide put into use at four different private gas-works. From two of these I have no returns, while the other two furnished samples which gave the following results:—

No. 1 Works.

After first revivification		6·4	per cent. sulphur.
„ second	„	9·6	„ „
„ third	„	14·3	„ „
„ fourth	„	17·8	„ „

No. 2 Works.

After first revivification		7·9	per cent. sulphur.
„ second	„	10·9	„ „
„ third	„	14·8	„ „

Then the experiments were discontinued, and the next sample was sent me without the revivification number, but it contained 27 per cent. of sulphur. The next sample sent was found to contain 38 per cent., and the last, a few days ago, contained 46 per cent.

In comparison, I may say that a sample of copperas, which had been in the purifiers 45 times, only contained 66 per cent. of sulphur.

It is well known that anhydrous oxide of iron, such as burnt pyrites, after years of exposure to the air and rain, will become to a small extent hydrated. Lunge, in 1866, patented a process for the use of burnt pyrites which had become hydrated by exposure to moisture and air, which process, I believe, is now carried out pretty largely by a firm at Armley, in Yorkshire. My experiments upon the hydration of burnt pyrites leads me to suppose that only a small proportion of the oxide of iron becomes hydrated, and that the purification is practically performed by the anhydrous oxide.

Still, though it will be found that an anhydrous oxide will purify coal gas, yet it must be admitted that a precipitated one is the best which can be used for the purpose, and, next to that, an hydrated. The absorption is quicker, and the revivification quicker, than an anhydrous oxide, and the resulting spent material is more valuable in the former cases.

There is no doubt that there are many inferior oxides offered to Gas Managers now, and, in order that the gas chemist may be able to properly value any sample which comes under his notice, I have devised the following test:—

Anhydrous oxide of iron is not very easily soluble in dilute acids, but the hydrated and precipitated oxides are very easily soluble. Take, therefore, 5 grammes of the material, and boil for half an hour gently with 1000 c.c. of dilute HCl, of 6° Twad. Filter and estimate the oxide of iron in the filtrate. This will be found a ready method. Another portion should then be taken, and the total iron oxide estimated. One gives the "active" oxide, and the difference between the two, the "potential" oxide.

And now, while upon this subject, I may as well describe a test which I have been using for determining whether an oxide is completely spent or not. It has been usual to estimate the sulphur which the spent oxide contains. This is not correct in principle, for the amount of sulphur must necessarily depend upon the quality of oxide used; therefore it is much better to be guided by the amount of oxide of iron, which dilute HCl will dissolve out.

The test is applied as before—5 grammes of the oxide in question are gently simmered for half an hour with 100 c.c. of pure hydrochloric acid of 6° Twad., and filtered, the oxide of iron in the filtrate being estimated in the usual way, and called "active" oxide; and from the results of my experiments it would appear that Gas Managers are very much of the same opinion as to when an oxide should be thrown out of use.

In the following tables, I give a few illustrations of some of the different purifying materials, examined for the purpose of this paper, and the second table shows the amount of iron oxide (active) and sulphur in various spent oxides when thrown out of use:—

No. of Sample.	"Active," Fe_2O_3.	"Potential," Fe_2O_3.	Remarks.
1	10·4	—	Precipitated oxide.
2	30·2	3·4	Bog ochre.
3	20·6	—	Dry copperas.
4	18·0	22·0	Hydrated purifying material.
5	2·0	50·0	Anhydrous oxide.
6	1·2	74·0	" "
7	12·8	32·4	Bog ochre.

The "active" oxide of iron absorbs sulphuretted hydrogen quickly, the "potential" only after a long time; still it does act if in a fine state of division.

The following spent oxides were thrown out of use:—

No. of Sample.	Per Cent. S.	Per Cent. "Active," Fe_2O_3.	Remarks.
1	41·7	3·3	Fully spent.
2	64·5	4·7	
3	47·9	3·3	
4	66·8	3·8	
5	39·3	4·5	
6	67·2	4·2	
7	41·7	9·8	These, with the exception of No. 7, were all put in use again.
8	17·1	12·5	
9	32·7	9·6	
10	40·0	6·8	
11	33·6	7·6	
12	42·0	9·0	

These experiments show that an oxide should not be thrown out of use before the "active" iron oxide has been reduced to 4 per cent.

MEETING OF THE SUBSCRIBERS TO THE BENEVOLENT FUND.

JUNE 19, 1878.

CORBET WOODALL, Esq., President, in the Chair.

The PRESIDENT intimated that the statement of accounts having been printed and circulated, he would move that they be received and adopted. This was unanimously agreed to.

The PRESIDENT then stated that it would be necessary to elect three gentlemen as Trustees to the Fund, in accordance with the rules, and he thought they could not do better than elect the existing Trustees to the Ordinary Funds, who were gentlemen in whom every one placed the highest confidence.

The SECRETARY said that he had applied to Mr. Newall, who had expressed his willingness to accept the office, but Mr. Hawksley had declined on account of advancing age. He, the Secretary, had understood from Mr. Goddard that he would be present on the first day of the meeting, and had, therefore, deferred applying to that gentleman until he could do so personally. He was sorry to say, however, that Mr. Goddard had not attended, and he was the more sorry, because he was afraid that ill-health was the cause. In the event of their electing Mr. Goddard to the office of Trustee, the resolution must, of course, be subject to his acceptance of the trust, and he thought it would be well to consider the possibility of Mr. Goddard declining, because he knew that gentleman's health was such that he might reasonably object to any increase of his duties and responsibilities.

It was then moved, seconded, and unanimously resolved—

> "That Mr. H. Newall, Mr. E. Goddard, and Mr. George Livesey be elected Trustees to the Benevolent Fund, and that, in the event of Mr. Goddard declining to serve, Mr. Warner be asked to accept the office."

The meeting was then brought to a close.

British Association of Gas Managers.

LIST OF SUBSCRIPTIONS, &c.,

Paid during the Year ending December 31, 1877.

ANNUAL SUBSCRIPTIONS.

Name.	Address.	For the Year.	£	s.	d.
Ambler, W.	Saltaire	1877		10	6
Arnott, J.	Leeds	1876	1	1	0
Andrews, W. W.	London	1877	1	1	0
Andrews, H. W.	Smyrna	„		10	6
Ashmore, W.	Stockton	„	1	1	0
Anderson, T.	Bath	„		10	6
Anderson, Geo.	London	„	1	1	0
Alsop, S.	Pinxton	„		10	6
Allan, G. A.	Newcastle-on-Tyne	„		10	6
Ayris, J.	Norwich	„	1	1	0
Andrews, T.	Swansea.	„	1	1	0
Aird, J.	London	„	1	1	0
Aird, J.	Great Bridge	„	1	1	0
Annan, J.	Wolverhampton	„	1	1	0
Brothers, F. W.	Blackburn	1876		10	6
		1877	1	1	0
Bailey, G. D.	London	„		10	6
Brothers, H.	London	1875-6-7	1	11	6
Bates W.	Worksop	1877		10	6
Brown, R.	Arbroath	„		10	6
Ball, T. B.	New Wortley	„	1	1	0
Beale, F.	Beckton	„		10	6
Braidwood, J. F.	London	„		10	6
Bouttell, T. H.	Sleaford	„		10	6
Barratt, W.	Grantham	„		10	6
Browning, J. T.	Plymouth	„	1	1	0
Bickerton, G.	Goole	„		10	6
Bruce, T.	Shotley Bridge	„		10	6
Brett, R. W.	Hertford	„		10	6
Bell, T.	Selby	„		10	6
Barratt, S.	Manchester.	„		10	6
Blackburn, J. U.	Hebden Bridge	„		10	6
Braddock, J.	Oldham	„		10	6
Blott, E. B.	Richmond	„		10	6
Bower, T.	Lytham	„		10	6
Bickford, J. M.	Carshalton	„		10	6
Botley, C. E.	Wormwood Scrubs	„		10	6
Bridge, W.	Cleckheaton	„		10	6
Belton, W.	South Shields.	„		10	6
Beal, W. E.	Maidenhead	„		10	6
Bewlay, H.	Birmingham	„	1	1	0
Bryan, E.	Beverley	„		10	6
	Carried forward		£29	18	6

Name.	Address.	For the Year.	£	s.	d.
	Brought forward		29	18	6
Barton, A.	Cowes	1877	1	1	0
Bush, T. J.	Beckton	„	1	1	0
Brown, C.	Wells	„		10	6
Box, W. W.	Crayford	„	1	1	0
Budden, J.	Poole	„		10	6
Broadberry, W. H.	Tottenham	„	1	1	0
Baker, E.	Reading	„	1	1	0
Bengough, jun., J. E.	Vienna	„	1	1	0
Braddock, J.	Manchester	„		10	6
Brickles, E.	San Felipe	„		10	6
Booth, jun., J.	Middlesborough	„		10	6
Bartholomew, H.	Glasgow	„	1	0	0
Bowen, H.	Cardiff	„	1	1	0
Broadhead, M.	Great Grimsby	„		10	6
Broadhead, J.	Great Grimsby	„		10	6
Broadberry, C.	Harwich	„		10	6
Brown, J.	Fairford	„		10	6
Bennett, W. C.	Tiverton	„		10	6
Brémond, L.	Versailles	„		10	6
Brace, T.	Monmouth	„		10	6
Blackledge, W.	Bacup	„		10	6
Browning, J. T.	Colchester	„	1	1	0
Brown, W.	Manchester	„	1	1	0
Bower, F.	Low Moor	„		10	6
Ball, J. B.	Loughborough	„		10	6
Burgess, J.	Huddersfield	„		10	6
Burgess, F. J.	Huddersfield	„		10	6
Bull, T.	Tamworth	„		10	6
Catlin, W. H.	Kilkenny	1876-7	1	1	0
Church, J.	London	1877		10	6
Chambers, W. H.	Lowestoft	„		10	6
Cornish, J. H.	Bridgwater	„		10	6
Crowe, H. G.	Wellington	„		10	6
Coles, H. A.	Todmorden	„		10	6
Cowan, W.	Edinburgh	„		10	6
Child, F.R.	Ilfracombe	„		10	6
Craven, C. A.	Dewsbury	„		10	6
Carr, W.	Halifax	„		10	6
Cox, J. H.	Sunderland	„		10	6
Cross, S.	Abergavenny	„		10	6
Cranmer, J. S.	Stratford-on-Avon	„		10	6
Copp, W. L.	Watchett	„		10	6
Cockcroft, J.	Littleborough	„		10	6
Cutler, G.	Whitehaven	„		10	6
Carr, J.	Todmorden	„		10	6
Cockey, H.	Frome	„	1	1	0
Cockey, F. C.	Frome	„	1	1	0
Church, G.	London	„		10	6
Corbett, W.	Stourbridge	„	1	1	0
Chadwick, J.	Oldham	„		10	6
Colson, A.	Birmingham	„		10	6
Clak, J.	London	„	1	1	0
Crook, T. R.	Portsea	„	1	1	0
Cowen, J. A.	Blaydon-on-Tyne	„		10	6
Crossley, T. C.	Guernsey	„		10	6
Cleland, W.	Linacre	„	1	0	0
Clarke, D.	Ashton-under-Lyne	„		10	6
Child, W. D.	Romford	„		10	6
Clark, H.	London	„	1	1	0
Colyer, F.	London	„		10	6
	Carried forward		£70	15	6

Name.	Address.	For the Year.	£	s.	d.
	Brought forward		70	15	6
Crookenden, I. A.	London	1877		10	6
Church, R.	Chichester	„	1	1	0
Copland, C.	Hull	„		10	6
Chapman, J. L.	Harrow	„		10	6
Cathels, E. S.	Montreal	1876		10	6
Croft, W.	Morley	1877		10	6
Cotton, E.	Uxbridge	„		10	6
Cross, W.	Leamington	„		10	6
Coombs, J. A.	Cheltenham	„		10	6
Cutler, S.	Millwall	„	1	1	0
Coulson, J. B.	Derby	„		10	6
Darwin, J. M.	Longton	1876		10	6
		1877		10	6
Dear, J. G.	Baldock	„		10	6
Dunn, J.	Roscommon	„		10	6
Deakes, J.	Worcester	„	1	1	0
Darney, R.	Faversham	„		10	6
Donaldson, A.	Edinburgh	„		10	6
Davis, W.	Hereford	1877-8	1	1	0
Dixon, C.	Horncastle	1877		10	6
Daniel, A. V.	Portishead	„		10	6
Dore, W.	Chepstow	„		10	6
Duff, W.	Morecambe	„		10	6
Dalgliesh, J.	Glossop	„		10	6
Duxbury, T.	Accrington	„		10	6
Dand, T.	Exeter	„		10	6
Dougall, J.	Aberystwith	„		10	6
Dawes, S.	Clevedon	„		10	6
Donaldson, A.	Queenstown	„		10	6
Davison, W.	Crewe	„		10	6
Dempster, J.	Elland	„	1	1	0
Dempster, jun., R.,	Elland	„	1	1	0
Dempster, sen., R.	Elland	„	1	1	0
Dunning, J.	Middlesborough	„		10	6
Dougall, A.	Hull	„		10	6
Drimmie, G.	Holywood	„		10	6
Dover, J.	Princes Risboro'	„		10	6
Dow, A. G.	King's Lynn	„	1	1	0
Doughty, F.	Margate	„	1	1	0
Daniel, W.	Dublin	„		10	6
Durkin, S. W.	Southampton	„	1	1	0
Dougall, A.	Kidderminster	„		10	6
Douglas, J.	Portsea	„	1	1	0
Downie, A.	Cleethorpes	„		10	6
Davies, J.	Kidsgrove	„		10	6
Davies, J.	Nantwich	„		10	6
Edmond, J.	Newtown	1877		10	6
Eunson, J.	Northampton	„	1	1	0
Eastwood C.	Batley	1878		10	6
Evans, T.	St. Marychurch	1877		10	6
Ellery, C. S.	Neath	„	1	1	0
Evans, F. J.	Brentford	„	1	0	0
Earle, N.	London	„		10	6
Elliott, J.	Ludlow	„		10	6
Eldridge, J.	Richmond	„	1	1	0
Eldridge, H. O.	Maidstone	„		10	6
Edwards, A. J.	Taunton	„		10	6
Edson, G.	Otley	„		10	6
Ely, J.	Abingdon	„		10	6
Eadington, J.	Blyth	„		10	6
	Carried forward		£110	2	0

Name.	Address.	For the Year.	£	s.	d.
	Brought forward		110	2	0
Fuller, T. C.	Ramsgate	1877		10	6
Furnivall, G. S.	Bradley Green	„		10	6
Fraser, A. C.	London	1876		10	6
Fleming, W.	Lancaster	1877		10	6
Ford, W.	Stockton-on-Tees	„	1	1	0
Frith, J. R.	Runcorn	„	1	1	0
Forrest, T.	Walker	„		10	6
Fiddes, W.	Bristol	„	1	1	0
Forbes, J.	Denby Dale	„		10	6
Farrand, C.	Croydon	„		10	6
Farrand, F. F.	Acton	„		10	6
Freeman, H. S.	Wandsworth	„	1	1	0
Farey, S.	Skipton	„		10	6
Foulis, W.	Glasgow	„	1	1	0
Fette, W. E.	Boston, U. S. A.	„	1	0	0
Greenaway, J.	Truro	1877		10	6
Goddard, E.	Ipswich	„	1	1	0
Graham, D.	Middleton	1876	1	1	0
Gill, J.	Bridgnorth	1877		10	6
Grimwood, C. W.	Sudbury	„		10	6
Gandon, C.	London	„		10	6
Green, B.	Carrickfergus	„		10	6
Gore, H.	London	1876-7	1	1	0
Gloag, R. F.	Stockton-on-Tees	1877		10	6
Garnett, G.	Ryde	„	1	1	0
Guyatt, T.	London	„	1	1	0
Gibbons, jun., B.	Dudley	„	1	1	0
Genever, E.	Dunedin, N.Z.	„		10	6
Greenfield, J.	Torquay	„		10	6
Good, R.	Carshalton	„		10	6
Garlick, J.	Kildwick	„		10	6
Gooch, G.	Bournemouth	„		10	6
Green, B.	Mitcham	„	1	1	0
Gibb, A.	Belfast	„		10	6
Gil, Claudio	Barcelona	„	1	1	0
Giles, T.	Cowes	„		10	6
Goddard, D. F.	Ipswich	1877-8	1	1	0
Hegarty, J.	Colombo	1877		10	6
Harris, J.	Ross	„	1	1	0
Hardick, T.	Salisbury	„	1	1	0
Holmes, T.	Pernambuco	1876-7	1	1	0
Hammond, J.	Lewes	1877		10	6
Hall, J.	Ballymena	„		10	6
Hislop, L.	Bothwell	„		10	6
Hancock, P.	Sandbach	„		10	6
Hutchinson, J.	Barnsley	„		10	6
Hutchinson, W.	Barnsley	„		10	6
Hutchinson, C. H.	Athens	„		10	6
Hall J.	St. Helen's	„		10	6
Hawkins, J. G.	Wigan	„		10	6
Hunter, R.	Stalybridge	„		10	6
Hastings, C. W.	London	„	1	1	0
Hunt, C.	Birmingham	„	1	1	0
Hunter, S.	Salford	„		10	6
Hepworth, J.	Carlisle	„		10	6
Harding, G.	Liverpool	„		10	6
Harvey, W.	Plymouth	„		10	6
Harris, J.	Plympton St. Mary	„		10	6
Hallsworth, S.	Armley	„		10	6
	Carried forward		£151	10	6

Name.	Address.	For the Year.	£	s.	d.
	Brought forward		151	10	6
Harper, H.	Kensal Green	1877		10	6
Hersey, T. C.	Notting Hill	„		10	6
Holman, S.	London	„		10	6
Hatch, H.	Woolton	„		10	6
Horsley, C.	London	„	1	1	0
Hodgson, J.	Ulverston	„		10	6
Hawksley, C.	London	„	1	1	0
Hathaway, H.	London	„	1	1	0
Harris, F. M.	Falmouth	„		10	6
Hart, G.	Wakefield	„		10	6
Harkewitz, H.	South Bank	„	1	1	0
Howell, E.	Yeovil	„		10	6
Hill, H.	Huyton	„		10	6
Hobson, J.	Sheffield	„		10	6
Hammond, W. R.	Deal	„		10	6
Hoile, J.	Folkestone	„		10	6
Hunter, D.	Greenwich	1876-6-7	1	11	6
Hersee, A.	London	1877		10	6
Holmes, W. C.	Huddersfield	„	1	1	0
Hunter, J.	Woolwich	„		10	6
Howitz, G.	Copenhagen	„	1	1	0
Harris, R.	Bow	„	1	1	0
Hall, J. T.	Prescot	„		10	6
Hislop, G. R.	Paisley	„	1	1	0
Henry, T.	Ebbw Vale	„		10	6
Hammond, W.	Hampton	„		10	6
Hammond, W.	Bognor	„		10	6
Helps, G.	Bath	„	1	1	0
Hunt, H.	Swindon	„		10	6
Hamilton, J.	Chertsey	„		10	6
Hartley, C. L.	Blackburn	1877-8	1	1	0
Irons, G. B.	Gosport	1877		10	6
Iddon, R.	Southport	„		10	6
Jowett, J.	Great Grimsby	1877		10	6
Jacobs, C.	Blackwater	„		10	6
Jones, C. E.	Chesterfield	„	1	1	0
Jones, R. H.	Dover	„		10	6
Jones, C. W.	Milan	„		10	6
Jones, W. R.	Monte Video	„		10	6
Jones, W. J.	Malta	„		10	6
John, H. T. A.	Messina	„		10	6
Jacques, J.	Stockport	„		10	6
Jolliffe, J. T.	Hendon	„		10	6
Jervis, J. J.	New Swindon	„	1	1	0
Jones, W.	Dalton-in-Furness	„		10	6
Jackson, R.	Richmond, Yorks.	„		10	6
Ker, A. P.	Birmingham	„	1	1	0
Kelly, R. R.	London	„	2	0	0
King, R.	London	„	1	1	0
King, W.	Liverpool	„	1	1	0
Keys, R. P.	London	„		10	6
Kershaw, R.	Calcutta	„	1	1	0
Kitt, A.	London	„	1	1	0
Key, W.	Glasgow	1876-7	1	1	0
Lewis, B.	Carmarthen	1877		10	6
Lord, E.	Whitworth	„		10	6
Loxley, T.	Church	„		10	6
	Carried forward		£193	8	6

Name	Address.	For the Year.	£	s.	d.
	Brought forward.		198	8	6
Layton, T.	Redditch	1877		10	6
Longworth, W.	Dukinfield	„		10	6
Laycock, J.	Keighley	„		10	6
Littlewood, W.	Manchester	„		10	6
Lowe, J.	Bridport	„		10	6
Lockwood, T.	Stalybridge	„	1	1	0
Lloyd, G. H.	Birmingham	„	1	1	0
Lass, A.	London	„	1	1	0
Lukey, R. J.	Falmouth	„		10	6
Leather, S. P.	Burnley	„		10	6
Livesey, G.	London	„	2	2	0
Livesey, F.	London	„	1	1	0
Loam, M. H.	Nottingham	„	1	1	0
Livesay, J. G.	Ventnor	„		10	6
Livesay, A. F.	Chale	„	1	1	0
Lane, G.	Aylesbury	„		10	6
Legg, H.	Ossett	„		10	6
Little, R.	Sittingbourne	„		10	6
Lupton, J.	Leeds	„		10	6
Lyne, J.	Wexford	„		10	6
Laing, R. J.	London	„	1	1	0
Leach, W. T.	Ventnor	„		10	6
Laidlaw, D.	Glasgow	„	2	2	0
Linging, R.	Etruria	„	1	1	0
Mitchell, H. J.	Hornsey	1875-6	1	10	0
Moon, W. J.	Scarborough	1877		10	6
McMillan, J.	Stoke-on-Trent	„		10	6
Marr, R.	Sandown	„		10	6
Methven, J.	London	1876-7	1	1	0
Middleton, J.	Wandsworth	1877		10	6
Mills, W. P.	Dartford	„		10	6
Murray, S.	Uttoxeter	„		10	6
Melling, T.	Rainhill	1876	1	0	0
Morton, R.	London	1877	1	1	0
Mackay, A.	Edinburgh	„		10	6
Mead, A.	Chelmsford	„	1	1	0
Mildred, M.	London	„	1	1	0
Mossmann, T.	West Hartlepool	„		10	6
Miles, W.	Clitheroe	„		10	6
Morland, R.	Gloucester	„		10	6
Martin, T. H.	New Barnet	„		10	6
Morton, J.	Ashford	„		10	6
Mearns, J.	Banbridge	„		10	6
Murray, M.	Bungay	„		10	6
Moore, T.	Macclesfield	„	1	1	0
McGilchrist, J.	Dumbarton	„		10	6
Markham, T. T.	London	„		10	6
May, T.	Canterbury	„	1	1	0
Martin, H. R. H.	Llanelly	„		10	6
Malam, G. D.	Bingley	„		10	6
Malam, A.	Dumfries	„		10	6
Monk, L.	Lanark	„		10	6
Mead, C. R.	Sutton	„	1	1	0
Mead, F.	Sutton	„	1	1	0
McCrae, J.	Bury St. Edmunds	„		10	6
Mackenzie, W.	Dunfermline	„		10	6
Meiklejohn, J.	Houghton-le-Spring	„		10	6
Morris, J.	Jersey	„	1	1	0
McDougall, J. T.	London	„	1	1	0
McDougall, A.	Manchester	„	1	1	0
	Carried forward		£239	10	0

Name.	Address.	For the Year.	£	s.	d.
	Brought forward		289	10	0
Martyn, J.	Wadebridge	1877		10	6
Mann, W.	Gunnersbury	„	1	1	0
Moor, W.	Fence Houses	„	1	1	0
Manning, H.	Hythe	„		10	6
Medhurst, jun., W.	Folkestone	„		10	6
Mudie, J.	Burton-on-Trent	„		10	6
Murphy, D.	Manchester	„		10	6
McPherson, A.	Kirkcaldy	„		10	6
Martin, J.	Ormskirk	„		10	6
Martin, M.	Drogheda	„		10	6
Miles, J.	Bolton	„		10	6
Manwaring, J.	London	„		10	6
Monnier, D.	Paris	„	1	1	0
McCrae, B. M.	Dundee.	„		10	6
Mortis, W. J.	Eltham	„		10	6
Murphy, A. M.	Cirencester	„		10	6
Marsland, J.	Newry	„		10	6
Monson, P.	London	„		10	6
Macnie, J.	Londonderry	„	1	1	0
Melling, T.	Rainhill	„	1	0	0
Merriman, J. D.	Pictou	1876-7	1	1	0
Newbigging, Thomas	Manchester	1877		10	6
North, W.	Stourbridge	„		10	6
Newton, R.	Oldham	„		10	6
Newall, H.	Manchester	„		10	6
Niven, J.	Clayton	„		10	6
Nicholls, J. S.	South Bank	„		10	6
Osborn, G. H.	Bromley	„		10	6
Ogden, S. R.	Blackburn	„		10	6
Oldfield, F. W.	Hull	„		10	6
Ohren, Magnus	London	„		10	6
Ohren, J.	Rio de Janeiro	„		10	6
O'Neill, J. W.	London	„	2	2	0
Ogg, D. W.	London	„		10	6
Osmond, W.	Dorchester	„		10	6
Orme, D.	Oldham	„	1	1	0
Price, E.	Hampton Wick	1877		10	6
Peaty, H.	Longport	1876-6-7	1	11	6
Pritchard, F.	Southport	1876		10	6
Porteous, W.	Hendon	1877		10	6
Parkinson, G. J.	Birmingham	1875-6	2	2	0
Parsons, W.	Atherstone	1877		10	6
Paterson, J.	Warrington	„	1	1	0
Parlby, W.	Sheffield	„		10	6
Phelps, J.	Marlborough	„		10	6
Paterson, R. O.	Cheltenham.	„	1	1	0
Paterson, T. O.	Rochdale	„		10	6
Proud, T.	Birmingham	„	1	1	0
Pike, E. S.	Ystrad	„		10	6
Price, R	Llandudno	„		10	6
Potter, A.	Newcastle-on-Tyne	„	1	1	0
Potter C. J.	Newcastle-on-Tyne	„		10	6
Penney. J. H.	S. Shields	„		10	6
Penny, A.	London	„	1	1	0
Peebles, D. B.	Edinburgh	„		10	6
Phillips, A. F.	St. Albans	„	1	1	0
Parsons, M. J.	Carnarvon	„		10	6
Pazzani, J.	Vienna	„		10	6
Packham, H. F.	Kingston-on-Thames	„	1	1	0
	Carried forward		£281	19	6

Name.	Address.	For the Year.	£	s.	d.
	Brought forward		281	19	6
Phillips, W. R	Luton	1877	1	1	0
Parsons, J. H.	Oswestry	„		10	6
Palmer, J. E.	Great Malvern	„		10	6
Peeks, H.	Thorne	„		10	6
Pepys, W. H.	Ehrenfeld	„	1	1	0
Pierson, H. S.	Wandsworth	„		10	6
Padfield, W. A.	Exeter	„		10	6
Prescott, W.	Prescot	„		10	6
Philps, W.	Dorking	„		10	6
Reid, J.	Edinburgh	1877		10	6
Robinson, C. R.	Coventry	„	1	1	0
Robinson, W. L.	Coventry	„	1	1	0
Reed, J.	Newport	„		10	6
Ridley, G.	Newcastle-on-Tyne	„		10	6
Reid, J.	Derby	„		10	6
Riley, J.	Brighouse	„		10	6
Reeves, J. S.	Bilston	„		10	6
Russell, J.	Uxbridge	„		10	6
Riley, F.	Bishop's Stortford	„		10	6
Richards, W.	London	1875-6	1	1	0
Russell, F.	Ilfracombe	1877		10	6
Rafarel, W. C.	Barnstaple	„	1	1	0
Roberts, W. H.	Newton Abbott	„		10	6
Rogers, G.	Hexham	„		10	6
Randall, J.	Tottenham	„	1	1	0
Richmond, J.	Worthing	„		10	6
Robinson, G. A.	Leicester	„	1	1	0
Robinson, C. S.	Leicester	„	1	1	0
Redman, J.	Haworth	„		10	6
Read, J.	Tunbridge Wells	„	1	1	0
Read, C.	Red Hill	„		10	6
Russell, W. J.	Croydon	„		10	6
Ross, R.	Hiogo	„		10	6
Singleton, H.	Dronfield	1876		10	6
Stephen, W. H.	Sydney	1877		10	6
Sapey, E.	Tamworth	„		10	6
Shaul, E.	Penrith	„		10	6
Simpson, P.	Rugby	„		10	6
Sainsbury, H.	Trowbridge	„		10	6
Stout, W.	Boston	„		10	6
Smith, W.	Darlington	„		10	6
Studholm, S.	Whitehaven	„		10	6
Saville, G. E.	Sowerby Bridge	„		10	6
Sparke, J. B.	Leeds	„		10	6
Surl, J.	Tralee	„		10	6
Syms, W.	Rochester	„	1	1	0
Smith, jun., W.	Hyde	„		10	6
Smith, J. R.	Padiham	1877		10	6
Stiven, W.	Inverness	1876		10	6
Stiven, D.	St. Thomas, D.W.I.	1877		10	6
Stevenson, G. E.	Peterborough	„	1	1	0
Scott, G.	Tunbridge Wells	„		10	6
Sidle, R. J.	Hythe	„	1	1	0
Steuart, D. V.	Bradford	„	2	2	0
Smedley, G.	Buxton	„		10	6
Storer, J.	Stafford	„	1	1	0
Sadler, S. A.	Middlesborough	„		10	6
Sellers, C.	York	„		10	6
Sheppard, R.	Horsham	„		10	6
	Carried forward		£321	17	6

Name.	Address.	For the Year.	£	s.	d.
	Brought forward.		321	17	6
Stevenson, G. W.	London	1877	3	3	0
Stansfield, W.	Exeter	„		10	6
Smith, E.	Droitwich	„		10	6
Shimeld, W.	Dundalk	„		10	6
Shone, C. G.	Southall	„	1	1	0
Stephenson, H. P.	London	„	1	1	0
Smith, J.	Sunbury	„		10	6
Stevens, F. J.	London	„	1	1	0
Swallow, D.	Bradford.	„	1	1	0
Stevenson, S. E.	Exeter	„	1	1	0
Stormonth, T.	St. Anne's-on-the-Sea	„		10	6
Smith, R.	Darlington	„		10	6
Stelfox, J.	Belfast	„	1	1	0
Stone, Thos.	Weymouth	„		10	6
Still, A. H.	Cork	„		10	6
Tinney, W. U.	Winchester	1877	1	1	0
Throsby, W. P.	Lincoln	1877	1	1	0
Tayler, J.	Fareham	1875-6	1	1	0
Thorns, A.	Farnley	1877	1	1	0
Thomas, J.	Bodmin	„		10	6
Terdrey, C.	Tavistock	„		10	6
Thorneloe, G.	London	„		10	6
Taylor, C.	Derby	„		10	6
Thomas, H.	Oldham	„	1	1	0
Tobey, H.	New Malton	„		10	6
Trewhitt, T.	West Hartlepool	„	1	1	0
Trewby, G. C.	Beckton	„	1	1	0
Travers, T.	Cork	„		10	6
Thomas, R. P.	Ware	„		10	6
Townsend, H.	Waltham Cross	„		10	6
Tallentire, T.	Lurgan	„		10	6
Timmins, J.	Leigh	„		10	6
Tindall, J.	Walsall	„		10	6
Tait, W.	Portadown	„		10	6
Venner, B. G.	Eton	1877		10	6
Varley, T.	Colne	„		10	6
Varley, W. H.	Colne	„		10	6
Valon, W. A.	Ramsgate	„		10	6
Vanheson, G. B.	Rochester	„		10	6
Wells, H. F.	Tredegar	1875-6	1	1	0
Wadeson, J.	Windsor	1877		10	6
Walker, W. A.	Elland	„		10	6
Winstanley, W.	Newcastle-under-Lyme	„		10	6
Winstanley, G.	Coventry	„		10	6
Wright, J.	Birmingham	„	1	1	0
Wright, W.	Shipley	„		10	6
Wright, C.	Saffron Walden	„		10	6
Woodward, J.	Spalding	„		10	6
Woodall, C.	London	„	1	1	0
Willey, H.	Exeter	„	1	1	0
Warner, W. J.	S. Shields	„		10	6
Wilkinson, P. H.	Harrogate	„		10	6
Whyte, P.	Cardiff	„		10	6
White, C.	Blaenavon	„		10	6
White, T. W. R.	Sherborne	„		10	6
Wilson, A. F.	London	„		10	6
Watson, W.	Sheffield	„		10	6
Whitaker, W. B.	Buenos Ayres	„		10	6
	Carried forward		£363	17	6

Name.	Address.	For the Year.	£	s.	d.
	Brought forward		363	17	6
Williams, A.	London	1877	1	1	0
Walduck, C. E.	London	„	1	1	0
Wilton, J.	Silvertown	„	1	0	0
Wood, W.	Barrow-in-Furness	„		10	6
Wood. A. H.	Hastings	„	1	1	0
Whitehead, W. S.	Bradford	„	1	1	0
West, J.	Maidstone	„	1	1	0
Woodruff, W. W.	Sandwich	„		10	6
White, W.	Woolwich	„		10	6
Whitaker, J. W.	Wakefield	„		10	6
Walker, T.	Wrexham	„		10	6
Watson, J.	Herne Bay	„		10	6
Wyld, J.	Manchester	„		10	6
White, E.	Birmingham	„		10	6
Waller, G.	Stroud	„		10	6
Webb, T.	Egham	„		10	6
Wright, W.	Brighton	„		10	6
Watson, S.	Tunstall	„		10	6
Walker, W. T.	London	„	1	1	0
Willis, W. H.	Gt. Yarmouth	„		10	6
Watson, J. H.	Edinburgh	„		10	6
Wimhurst, H.	Andover	„		10	6
Warsop, H.	East Croft	„		10	6
Wilson, W. P.	London	„		10	6
Wrigley, E. G.	Ashton-under-Lyne	„		10	6
Wates, P. J.	Greenwich	„	1	1	0
Whyte, J.	Seaham Harbour	„		10	6
Woodall, H.	Leeds	„	1	1	0
Wilkinson, T.	Newmarket	„		10	6
White, W.	Abersychan	„		10	6
Wright, G.	Redcar	„		10	6
Walton, T.	Shrewsbury	„		10	6
Whitehead, J.	Dronfield	„		10	6
Waters, G. R.	Portland	„		10	6
			£386	18	6

SALE OF REPORTS.

		£	s.	d.
R. L. Andrews	London		4	10
F. C. Ramshaw	Great Grimsby		5	4
W. Stiven	Inverness		6	3
A. J. Dove	London	2	8	0
A. Penny	London	2	8	0
H. Thomas	Oldham		6	0
T. L. Sheppard	Farnworth		6	0
A. Gibb	Belfast		6	4
A. Penny	London		5	6
T. Bower	Lytham		10	8
Ready money sales of Reports to booksellers and others		3	15	3
		£11	2	2

ENTRANCE FEES.

		£	s.	d.
T. Lockwood	Stalybridge	5	0	0
S. Hallsworth	Armley	5	0	0
W. Corbet	Stourbridge	5	0	0
J. Dempster	Elland	5	0	0
R. Dempster, jun.	Elland	5	0	0
J. Wright	Birmingham	5	0	0
E. G. Wrigley	Ashton-under-Lyne	5	0	0
		£35	0	0

BRITISH ASSOCIATION OF GAS MANAGERS.

Dr. BALANCE-SHEET, DECEMBER 31, 1877. Cr.

May 1, 1877.	£	s.	d.
To Balance brought forward	354	6	11
Dec. 31.			
To Annual Subscriptions	386	18	6
„ Sale of Reports	11	2	2
„ Entrance Fees from Extra-ordinary Members	35	0	0
„ Dividends on Railway Stock and Shares	6	8	5
„ Interest allowed by Treasurer		17	4
	£794	13	4

Audited and found correct,

(Signed)
ALFRED HERSEE, } *Auditors.*
ALFRED LASS, }

25th March, 1878.

Dec. 31, 1877.			£	s.	d.
By Printing, Stationery, and Postages.			56	15	6
„ Expenses of Meeting in Bristol			40	6	4
„ T. Cargill's Fee and Expenses			14	4	9
„ Value of Premium awarded to Mr. Richards			17	0	0
„ Do. do. to Mr. Hunt					
„ Printing, Lithographing, Binding Reports, and Advertising			123	9	9
„ Travelling Expenses of Committee			9	8	9
„ Secretary's Salary			140	0	0
„ Office Rent			20	0	0
„ Banker's Charge					7
„ Petty Cash Disbursements			2	12	2
Invested in Manchester, Sheffield, and Lincolnshire Railway Shares	£64	5 0			
Ditto in Great Western Railway 5 per Cent. Stock	233	10 6			
In Treasurer's hands	20	11 7			
Ditto for Investment	10	10 0			
In Secretary's hands	15	7 6			
At Banker's	26	10 11			
			370	15	6
			£794	13	4

BRITISH

Association of Gas Managers.

RULES AND REGULATIONS

AND

LIST OF MEMBERS.

JUNE, 1878.

PUBLISHED FOR THE ASSOCIATION BY

W. H. BENNETT, *Secretary*,

22, GREAT GEORGE STREET, WESTMINSTER.

OFFICE-BEARERS.—1878-79.

President.

W. J. WARNER, Gas-Works, South Shields.

Vice-Presidents.

JOHN DOUGLAS, Gas-Works, Portsea.
GEORGE WILSON STEVENSON, 4, Westminster Chambers, Victoria Street, Westminster, S.W.
CHARLES HUNT, Gas-Works, Windsor Street, Birmingham.

Trustees.

EBENEZER GODDARD, Gas-Works, Ipswich.
THOMAS HAWKSLEY, 30, Great George Street, Westminster, S.W.
HENRY NEWALL, 10, Marsden Street, Manchester.

Treasurer.

HENRY NEWALL, 10, Marsden Street, Manchester.

Secretary.

WILLIAM H. BENNETT, 22, Great George Street, Westminster, S.W.

Committee.

JOHN STORER, Gas-Works, Stafford.
FRANK LIVESEY, South Metropolitan Gas-Works, Old Kent Road, London, S.E.
ROBERT ORMISTON PATERSON, Gas-Works, Cheltenham.
ROBERT HARRIS, Gas-Works, Bow Common, London, E.
ALFRED H. WOOD, Gas-Works, Hastings.
JOSEPH HEPWORTH, Gas-Works, Carlisle.
ROBT. HESKETH JONES, Gas Offices, Dover.
WILLIAM CARR, Gas-Works, Halifax.
JAMES BRADDOCK, Gas-Works, Rochdale Road, Manchester.

Finance Committee.

GEORGE T. LIVESEY, South Metropolitan Gas-Works, Old Kent Road, London, S.E.
JAMES ELDRIDGE, Gas-Works, Richmond, Surrey.
GEORGE WILSON STEVENSON, 4, Westminster Chambers, Victoria Street, Westminster, S.W.

The following are, *ex officio*, also Members of the General Committee:—

EBENEZER GODDARD, Gas-Works, Ipswich.
THOMAS HAWKSLEY, 30, Great George Street, Westminster, S.W.
GEORGE T. LIVESEY, South Metropolitan Gas-Works, Old Kent Road, London, S.E.
JAMES ELDRIDGE, Gas-Works, Richmond, Surrey.
HENRY NEWALL, 10, Marsden Street, Manchester.
GEORGE WILSON STEVENSON, 4, Westminster Chambers, Victoria Street, Westminster, S.W.
JOHN DOUGLAS, Gas-Works, Portsea.
CORBET WOODALL, Phœnix Gas-Works, Vauxhall, London, S.W.
W. J. WARNER, Gas-Works, South Shields.
CHARLES HUNT, Gas-Works, Windsor Street, Birmingham.
WILLIAM H. BENNETT, 22, Great George Street, Westminster, S.W.

Auditors.

ALFRED HERSEE, 29, Great St. Helen's, London, E.C.
ALFRED LASS, 30, Gracechurch Street, London, E.C.

Office.

22, GREAT GEORGE STREET, WESTMINSTER, S.W.

REGULATIONS.

SECTION I.—Object.

1.—This Association shall devote itself to the encouragement and advancement of all matters connected with Gas Engineering, Manufacture, and Finance — being established to facilitate the exchange of information and ideas among its Members.

SECTION II.—Constitution.

2.—This Association shall consist of Ordinary, Extra-Ordinary, and Honorary Members.

3.—Ordinary Members shall be either Engineers, Managers, or Secretaries of Gas-Works [except in special cases in which the Committee may deem it necessary that the rule shall be relaxed], who may make application for membership and be admitted.

4.—Extra-Ordinary Members shall consist of gentlemen taking an interest in matters connected with Gas-Works, and shall only be admitted upon being elected at the Annual General Meeting of the Association by a majority of two-thirds of the Members present, and will be allowed to take part in its proceedings. Besides paying the Annual Subscription, they will pay an Admission Fee of £5.

5.—Honorary Members shall be gentlemen who take a deep interest in matters connected with Gas Engineering, and whose scientific or practical knowledge recommends them to the Association.

SECTION III.—Management.

6.—The Management of the affairs of the Association shall be confided to a Committee, subject to the control of the General Meetings.

7.—The Officers shall consist of a President, three Vice-Presidents, Treasurer, Secretary, nine Members of Committee, and three

Members of Finance Committee, to be elected at the General Meeting, in the manner hereinafter directed. The President, Past President, or Acting President for the preceding year, Vice-Presidents, Treasurer, Trustees, Finance Committee, and Secretary shall be *ex officio* members of the General Committee. Five to be a quorum.

SECTION IV.—Duties of Office-bearers.

8.—The Office-bearers shall assume office immediately after the meeting at which they are elected. They shall hold meetings, and make arrangements for carrying out the objects of the Association.

9.—The President shall take the chair at all meetings at which he is present. He shall conduct and keep order, state and put questions, and, if necessary, ascertain the sense of the meeting upon matters before them. He may sum up, at the termination of discussions, the opinions given, and declare what appears to be the object or intention of the speaker, to which he may add his own opinion; and he shall carry into effect the regulations of the Association.

10.—The Vice-Presidents shall take part in the proceedings, and one of them shall take the chair in the absence of the President, and perform the duties enumerated in the preceding regulation. In the absence of the President and Vice-Presidents, a Chairman to be nominated from the other members of the Committee.

11.—The Secretary shall, on being appointed, receive all moneys, and pay the same to the banking account of the Association. He shall also take minutes of the proceedings at all the meetings of the Association, and enter them in proper books provided for the purpose. He shall write the correspondence, read minutes and notices at all the meetings, and also papers and communications, if the authors wish it, report discussions, and perform whatever other duties may be indicated in the regulations of the Association as appertaining to his department.

12.—The duties of the Treasurer shall be to keep in safe custody the funds of the Association.

13.—The Finance Committee shall meet periodically to receive from the Secretary a statement of accounts, and make all payments by cheque, signed by at least two members of such Committee, and countersigned by the Secretary.

SECTION V.—AUDITORS.

14.—Two Auditors, who shall be Members of the Association, but not Office-Bearers, shall be chosen at each General Meeting, to examine the accounts and statements produced by the Secretary and Treasurer.

SECTION VI.—MEETINGS AND PROCEEDINGS.

15.—The Association shall hold General Meetings annually, at such time and place as shall be arranged at the previous General Meeting.

16.—At every General Meeting of the Association, the Secretary shall first read the minutes of the preceding meeting, which, on approval, shall be signed by the Chairman; the Secretary shall next read any notices or papers which may be brought before the meeting, after which new Members shall be admitted. Any business of the Association shall then be disposed of, and any communications or papers for the day be read.

17.—The Secretary shall issue notices to all Members of the Association at least fourteen days before each General Meeting, mentioning the papers to be read, and the business to be brought forward at the meeting.

18.—The Committee shall meet one hour before each meeting of the Association, and on other occasions when the President shall deem it necessary, of which notice shall be given by special circulars.

19.—All questions to be decided by any convenient system of open voting, the Chairman to have a second or casting vote when necessary. Questions of a personal nature shall be decided by ballot.

20.—Any Member, with the concurrence of the Chairman, shall have power to admit a friend to each meeting of the Association,

[illegible] shall [illegible] take any part in the discussions, unless requested [illegible] by the Chairman of the Meeting.

21.—All papers read at the meetings of the Association must relate to matters either directly or indirectly connected with the objects of the Association, and must be approved of by the Committee before being read.

22.—All papers, drawings, or models submitted to these meetings shall remain the property of their authors, and the Association shall afford every facility for giving this rule practical effect.

SECTION VII.—Elections of New Members and Office-Bearers.

23.—Every applicant for membership shall signify the same in writing to the Secretary, who shall, thereafter, submit it to the Committee, to be considered and brought by them before the next meeting of the Association for approval.

24.—Honorary Members shall be proposed to or by the Committee, and notice thereof shall be given by the Secretary at the next meeting of the Association, who shall admit them, if approved by two-thirds of the Members present.

25.—New Members to be formally introduced by the Chairman after being elected, when their names shall be entered in a roll-book of the Association, and they shall at the same time receive a copy of the regulations.

26—If any person proposed for membership, on being balloted for, be rejected, no notice shall be taken of the proposal in the minutes.

27.—The President, Vice-Presidents, Treasurer, and Secretary shall be elected annually.

28.—The President shall in no case hold that office for a longer period than one year; and, at the expiration of such period, he shall not be re-eligible for that office for the period of three years.

29.—Three Members of the Committee shall retire annually in rotation, and be ineligible for re-election during the following year.

30.—The Committee shall, previous to the Annual Meeting in each year, prepare a list of Members whom they nominate as suitable for the offices of President, Vice-Presidents, Treasurer, and Secretary for the ensuing year. The list shall also contain the names of Twelve Members who have been nominated as fitted to become Members of the Committee, and three Members to serve as a Finance Committee. It shall be open to any Member to propose another as a Member of Committee. If the proposal is duly made, and supported by the names of two other Members, and sent to the Secretary on or before the 31st of March preceding the Annual Meeting, the Committee shall accept the nomination, and include the name of the gentleman so proposed in the voting list. No Member shall propose or support the nomination of more than one Member of Committee in the same year. The number of names to be nominated by the Committee shall be reduced from twelve, as at present, to six; but in the event of there not being six names nominated by other Members, the Committee shall fill up the number to twelve, as required by the rule. A copy of such list to be forwarded to each Member of the Association before the Annual General Meeting, and each Member shall be at liberty to make a selection from the list, or to substitute the name or names of any other Member or Members for each respective office; but the number of names so selected or substituted must not in any case exceed the number to be elected to the respective offices.

SECTION VIII.—Contributions of Members to the Association.

31.—Every Ordinary Member shall contribute the sum of not less than 10s. 6d. annually, and every Extra-Ordinary Member elected in the year 1877, and prior thereto, shall contribute a sum of not less than 10s. 6d. per annum, but every Extra-Ordinary Member elected subsequent to the year 1877 shall subscribe Two Guineas per year.

32.—Honorary Members shall not be required to pay any contributions.

33.—The Annual Contributions are due on the 1st day of January in each year, and shall be payable in advance.

34.—No Member whose contribution is in arrear shall be entitled to vote, or to receive a copy of the Report of Proceedings.

35.—Any Member retiring from the Association shall continue to be liable for annual contributions which shall have accrued due previously to the time at which he shall have given written notice of his retirement to the Secretary.

36.—Any Member may compound for his Annual Subscription by the payment in one sum of Ten Guineas. All such compositions shall be invested in the names of three Trustees, and the interest alone shall be appropriated to the current expenditure of the Association, except by special direction of the Committee.

37.—The Committee shall bring before the Members at every Annual General Meeting the names of such persons as may have allowed their subscriptions to fall into arrear for two consecutive years, exclusive of the current year, whereupon the defaulters shall be struck off the list, and cease to have any advantage, right, or privilege in the Association, unless sufficient cause is shown to the contrary. In the event, however, of any Member paying up all his arrears, he shall be entitled to re-admission without re-election.

SECTION IX.—Bye-Laws.

38.—Any proposition for adding to or altering the regulations shall be laid before the Committee, who may bring it before the Association, if they think fit, and who shall be bound to do so on the requisition, in writing, of any five Members of the Association.

39.—Each Member of the Association shall be annually furnished by the Secretary with a copy of the Rules and Regulations, and also with a list of the names and residences of the Members, provided that his subscription has been paid.

BRITISH ASSOCIATION OF GAS MANAGERS.

LIST OF MEMBERS.

The Figures preceding the Names indicate the Date of Election.
*A * prefixed to the Date denotes that the Member is a Contributor to the Benevolent Fund.*

HONORARY MEMBERS.

	NAME.	ADDRESS.
*1864	Blackburn, James	Gas-Works, Calcutta
1878	Dresser, G. Warren	42, Pine Street, New York, U.S.A.
1866	Durand, Emile	72, Faubourg Montmartre, Paris
1877	Glaisher, Jas.	Blackheath
*1873	Hartley, Fredk. W.	55A, Millbank Street, Westminster, S.W.
1864	Hawksley, Thomas (*Trustee and Past President*)	30, Great George Street, Westminster, S.W.
1878	Lebon, Eugène	15, Rue Drouot, Paris
1873	Macadam, Dr. Stevenson ..	Surgeon's Hall, Edinburgh
1878	Mallet, Alfred	54, Boulevard de la Vilette, Paris
1868	Odling, Dr.	Oxford
1877	Richardson, Wm.	62, Pershore Rd., Edgbaston, Birmingham
1878	Servier, Edouard	18, Rue de Maubeuge, Paris
1873	Sugg, William T.	Vincent Works, Vincent Street, Westminster, S.W.
1878	Vautier, Emile	30, Quai St. Antoine, Lyons, France

(*Number of Honorary Members*, 14.)

ORDINARY MEMBERS.

1866	Allan, Geo. A.	Gas-Works, Willington Quay, near Newcastle-upon-Tyne
1873	Alsop, Samuel..	Gas-Works, Pool Close, Pinxton, Alfreton
*1871	Ambler, William	Gas-Works, Saltaire, Bradford
*1866	Anderson, Geo.	35A, Great George Street, Westminster, [S.W.
*1868	Anderson, Thomas	Gas-Works, Bath
1871	Andrews, Henry Ward	Gas-Works, Smyrna
1864	Andrews, Thornton	Gas-Works, Swansea
1866	Annan, John	Gas-Works, Wolverhampton
1873	Armitage, Charles	Gas Office, Dewsbury
1867	Arnott, John	53, Belle Vue Road, Leeds
1876	Ashley, William	Gas-Works, Tenbury

	Name.	Address.
1876	Ashton, Joseph Chapel	Gas-Works, Old Swindon, Wilts
1877	Ayris, John	Surrey Street, Norwich.
*1868	Backler, Henry M'L.	11, Austin Friars, London, E.C.
1873	Bailey, George Daniel	Gas-Works, Kensal Green, London, W.
1871	Bailey, William	Gas-Works, Camborne, Cornwall
1868	Baker, Edward	Gas-Works, Reading
1868	Ball, John B.	Gas-Works, Loughborough
*1876	Ball, T. Banbury	Gas-Works, New Wortley, near Leeds
1876	Barnett, E.	Barrack Gas-Works, Fermoy, Co. Cork
1875	Barnley, Frederick..	Gas-Works, Alton, Hants
1877	Barratt, Samuel	Corporation Gas-Works, Gaythorn, Man-
1870	Barratt, William	Gas Office, Grantham [chester
1864	Bartholomew, H.	Glenorchard, Torrance of Campsie, near Glasgow
1871	Barton, Alfred	Union House, West Cowes, Isle of Wight
*1867	Bates, William	Gas-Works, Worksop
1876	Beal, William Earl	5, High Street, Maidenhead
1870	Beale, Frederick	Gas-Works, Beckton, North Woolwich, E.
1864	Bell, Thomas	Gas-Works, Selby
1875	Belton, William	5, Ravensbourne Terrace, South Shields
1876	Bengough, Jun., John E. ..	Gas-Works, Währing, Vienna, Austria
1876	Bennett, William Cuthbert ..	Gas-Works, Tiverton
1872	Berry, George..	Ashford
*1875	Bickerton, George	Gas-Works, Goole, Yorkshire
1877	Bickford, J. M.	Gas-Works, Carshalton, Surrey
1864	Billows, H. B.	29, Camden Road, London, N.W.
1875	Blackburn, John Uttley.. ..	Gas-Works, Hebden Bridge
1864	Blackledge, William	Gas-Works, Bacup
1877	Blott, E. B.	Gas-Works, Richmond, Surrey
*1865	Booth, Jun., John	Gas-Works, Middlesborough
*1875	Botley, Charles Edward ..	Gas-Works, Mitre Lane, Wormwood Scrubs, W.
*1867	Bouttell, Thos. Hy.	Gas-Works, Sleaford
*1864	Bowen, Henry	Gas-Works, Cardiff
1870	Bower, Frederick	Gas-Works, Low Moor, North Bierley, near Bradford
1877	Bower, Thos.	Gas-Works, Lytham
*1871	Box, William W.	Gas-Works, Crayford, Kent
1877	Brace, Thos.	Gas and Water-Works, Monmouth
*1869	Braddock, Jas. (*Mem. of Com.*)	Gas-Works, Rochdale Road, Manchester

	Name.	Address.
1874	Braidwood, J. F.	Phœnix Gas Office, Bridge Foot, Vauxhall, S.W.
1876	Brémond, Lucien	Compañia Madrileña de Alumbrado y Calefaccion por Gas, Madrid
*1872	Brett, Robert William	Gas-Works, Hertford
1867	Brickles, Edward	Gas-Works, San Felipe, Chili
1874	Bridge, R.	The Plant, Doncaster
1877	Bridge, Wm.	Gas-Works, Dukinfield
1875	Broadberry, Charles	Gas-Works, Harwich
1878	Broadberry, F.	Gas-Works, Southend
*1872	Broadberry, William Henry..	Gas-Works, Tottenham, N.
1873	Broadhead, James	Gas-Works, Great Grimsby
1864	Broadhead, M.	Great Grimsby
1872	Brothers, Francis William ..	Livesey Chemical Works, near Blackburn
1869	Brothers, Horatio	Gas-Works, Kensal Green, London, W.
*1871	Brown, Allan	Gas-Works, Woodford, Essex
1873	Brown, Charles	Gas-Works, Wells, Somerset
1866	Brown, John	Gas-Works, Fairford, Gloucestershire
1867	Brown, William	Victoria Foundry, 43, City Road, Manchester
1874	Browning, J. T.	Gas-Works, Plymouth
1874	Browning, J. T.	Gas-Works, Colchester
1876	Bruce, Thomas	Gas-Works, Shotley Bridge
*1872	Bryan, Eli	Gas-Works, Beverley
1875	Budden, John	Gas-Works, Poole
1867	Bull, Thomas	Gas-Works, Tamworth
1877	Burgess, F. J.	Gas-Works, Huddersfield
1867	Burgess, John	Gas-Works, Huddersfield
1874	Bush, T. J.	Gas-Works, Sydney, New South Wales
1878	Canning, Thos.	Gas-Works, Newport, Monmouthshire
1878	Carpenter, Stephen	Gas-Works, Bow Common, London, E.
*1868	Carpenter, W. T.	Gas-Works, Sheerness
1877	Carr, Isaac	10, Crownpoint Road, Hunslet, Leeds
1876	Carr, William (*Mem. of Com.*)	Gas-Works, Halifax, Yorkshire
1878	Carter, Henry Ward	Gas-Works, Winsford, Cheshire
1864	Cathels, E. S.	Hamilton, Ontario, Upper Canada
1871	Catlin, William Henry	Gas-Works, Kilkenny
1875	Chadwick, John	Gas-Works, Oldham
1865	Chambers, W. H.	Gas-Works, Lowestoft
1874	Chapman, J. L.	Gas-Works, Harrow, Middlesex

	Name.	Address.
1878	Chester, Wm. Reginald.. ..	Phœnix Gas-Works, Greenwich, S.E.
1878	Chapman, John	Gas-Works, Harrow, Middlesex
1870	Child, Frederick R. .. .	Gas-Works, Ilfracombe
1874	Child, W. D.	Gas-Works, South Street, Romford
*1874	Church, G. F...	5, Wilmington Square, London, W.C.
*1873	Church, Jabez..	17B, Great George Street, Westminster.
1864	Church, Robert	Gas-Works, Chichester [London, S.W.
1870	Clark, Henry	Gas-Works, Great Cambridge Street, Hackney Road, London, E.
1870	Clark, John	Gas-Works, King's Cross, London, N.
1872	Clarke, David	Gas-Works, Ashton-under-Lyne
*1875	Cleland, William	Gas-Works, Linacre, Liverpool
1876	Cleminshaw, Thomas Stanley	Gas-Works, Christchurch, Canterbury, New Zealand
1868	Cocker, John Lees	Gas-Works, Merthyr Tydvil
1865	Cockey, Henry	Gas-Works, Frome, Somerset
1867	Cockcroft, John	Gas-Works, Littleborough
1873	Coles, Henry A.	Gas-Works, Todmorden
1876	Colson, Alfred..	Gas-Works, Windsor Street, Birmingham
*1875	Coombs, John A.	Gas-Works, Cheltenham
1864	Cooper, W. R...	Gas-Works, Banbury
1876	Copp, Walter Lewis	Gas-Works, Watchet, Somerset
1870	Cornish, James Hughes ..	Gas-Works, Bridgwater
1877	Cotton, Edwin	Gas-Works, Uxbridge
1869	Coulson, James B...	92, Friar Gate, Derby
1866	Cox, John H.	Gas-Works, Sunderland
1872	Cranmer, Job Seymour	Gas-Works, Stratford-on-Avon
1864	Craven, Charles A.	Gas-Works, Pernambuco
1875	Croft, William	Gas-Works, Morley, near Leeds
1867	Croll, Col. A. Angus (*Past Pres.*)	41, Wool Exchange, Coleman Street,
1874	Crook, T. R...	Gas-Works, Portsea [London, E.C.
1869	Crookenden, Isaac Adolphus..	Phœnix Gas Office, 70, Bankside, London,
*1870	Cross, Samuel..	Gas-Works, Abergavenny [S.E.
1875	Cross, William	Gas-Works, Leamington
1872	Crossley, Thomas C.	Gas-Works, Guernsey
1867	Crowe, Henry G.	Gas-Works, Wellington, Somerset
1878	Culver, George	Gas-Works, Hythe, Kent
*1872	Cutler, George..	New Gas-Works, Whitehaven
1878	Daley, William	Gas-Works, Invercargill, Southland, New
1876	Dalgliesh, James	Gas-Works, Glossop [Zealand
1864	Dand, Thomas..	Linden Vale, St. David's, Exeter

	Name.	Address.
1877	Daniel, Atchason V.	Gas-Works, Portishead, Somerset
1871	Daniel, William	55, Mary Street, Dublin
1878	Darney, Jun., Robert	Gas-Works, Bournemouth
*1868	Darney, Robert	Gas-Works, Faversham
*1869	Darwin, James Malam	Gas-Works, Longton, Staffordshire
1867	Darwin, S. B...	Gas-Works, Shrewsbury
1867	Davies, John	Gas-Works, Kidsgrove
*1876	Davies, John	Gas-Works, Nantwich
1878	Davis, George J.	Gas-Works, Fazeley Street, Birmingham
1868	Davis, William	Gas-Works, Hereford
1877	Davison, William	Gas-Works, Crewe
1877	Dawes, Samuel	Gas-Works, Clevedon, Somerset
1878	Dawson, W. C.	Gas-Works, Arundel, Sussex
1867	Deakes, Josiah	Gas-Works, Worcester
1871	Dear, James Gilbert	Gas-Works, Baldock, Herts
*1864	Dempster, R.	Gas Engineer, Elland
*1872	Dixon, Charles	Gas-Works, Horncastle, Lincolnshire
1876	Donaldson, Andrew	Gas-Works, Queenstown, Ireland
1877	Donaldson, Geo.	35A, Gt. George Street, Westminster, S.W.
1867	Donaldson, John	Gas-Works, Dover
1865	Dore, William	Gas-Works, Chepstow
1871	Dougall, Andrew	Gas-Works, Kingston-upon-Hull
1872	Dougall, Archibald..	Gas-Works, Kidderminster
1877	Dougall, Jas.	Gas-Works, Aberystwith, South Wales
*1870	Doughty, Frederick	Gas-Works, Margate
1873	Douglas, David	
1866	Douglas, John (*Vice-President*)	Gas-Works, Portsea
1866	Douglas, Robert	West Grove House, Emsworth, Hants.
1868	Douglas, Thomas	Cross House, Aldershot
1873	Dover, John William	Gas-Works, Princes Risborough, Bucks
1875	Dow, Arthur Graham	Gas-Works, King's Lynn
1874	Downie, A...	Gas-Works, Cleethorpes, nr. Gt. Grimsby
1878	Dozell, Henry	11, Austin Friars, London, E.C.
1873	Drimmie, George	Gas-Works, Holywood, Ireland
1870	Duff, William..	Gas-Works, Morecambe
*1876	Dunn, James	Gas-Works, Roscommon, Ireland
1875	Dunlop, William	Gas-Works, Hamilton, N.B.
1864	Dunning, John	Middlesbrough
1874	Durkin, S. W.	Gas-Works, Southampton
1875	Dyson, Edward	Gas-Works, St. Helen's
1876	Duxbury, Thomas	Gas-Works, Darwen

	Name.	Address.
1869	Eadington, James	Gas-Works, Blyth, Northumberland
1873	Earle, Norwood	80, Cannon Street, London, E.C.
1874	Eastwood, C.	Corporation Gas-Works, Batley, Yorkshire
*1871	Edmond, James	Gas-Works, Newtown, Montgomeryshire
1872	Edson, George..	Gas-Works, Otley, near Leeds
*1873	Edwards, Alfred James	Gas-Works, Taunton
1870	Eldridge, Henry Oswald ..	Gas-Works, Maidstone
*1865	Eldridge, James (*Member of Finance Committee*)	Gas-Works, Richmond, Surrey
1874	Ellery, C. S.	Gas-Works, Neath, Glamorganshire
*1875	Elliott, James..	Gas-Works, Ludlow
*1874	Ely, J.	Gas-Works, Abingdon
1872	Eunson, Jun., John	Gas-Works, Northampton
*1870	Evans, Frederick John	Clay Ponds, Brentford
1877	Evans, Thos.	Gas-Works, St. Mary Church, Torquay
1868	Everist, Henry Thomas.. ..	
*1872	Farrand, Frank Frederick ..	5, Falfield Terrace, Shakespeare Road, Acton, W.
*1870	Farrand, Charles	Gas-Works, Croydon
1874	Farey, S...	Gas-Works, Skipton
*1873	Fergusson, William	Gas-Works, Neepsend, Sheffield
1877	Fette, W. Eliot	11, Walnut Street, Boston, Mass., U.S.A.
1865	Fiddes, Walter	Gas-Works, Bristol
*1870	Fish, Robert	Gas-Works, Bucharest
1864	Fleming, W.	Gas-Works, Lancaster
*1873	Forbes, John	Denby Dale, near Huddersfield
1868	Ford, William..	Gas-Works, Stockton-on-Tees [Tyne
1868	Forrest, Thomas	Gas-Works, Walker, near Newcastle-upon-
1870	Foulis, William	Gas Office, 42, Virginia Street, Glasgow
1864	Fraser, A. C.	Gas-Works, Barrow-in-Furness
1877	Freeman, Hy. S.	Gas-Works, Wandsworth, Surrey
*1864	Frith, J. R.	Gas-Works, Runcorn
*1873	Fuller, Thomas Christopher ..	2, St. Mary's Villas, The Elms, Ramsgate
*1873	Furnivall, George Steele ..	Gas-Works, Bradley Green, near Congleton
1876	Gandon, Charles	Crystal Palace District Gas-Works, Lower Sydenham, S.E.
1875	Garlick, John..	Gas-Works, Kildwick, West Riding of Yorkshire
*1864	Garnett, George	Gas-Works, Ryde, Isle of Wight
1871	Genever, E.	Gas-Works, Dunedin, New Zealand

	Name.	Address.
1871	Gibb, Andrew	Gas-Works, Ormeau Road, Belfast
1877	Gil, Claudio	Gas-Works, Barcelona, Spain
1864	Giles, Thomas	Gas-Works, Cowes, Isle of Wight
1872	Gill, Joshua	Gas-Works, Bridgnorth, Salop
1875	Gloag, Robert Ford	Gas-Works, Stockton-on-Tees
1872	Goddard, D. Ford	Gas-Works, Ipswich
*1864	Goddard, E. (*Trustee and Past President*)	Gas-Works, Ipswich
1872	Goldsmith, George	Gas-Works, Leicester
1875	Gooch, George	Gas-Works, Bournemouth, Hants
*1872	Good, Robert	Gas-Works, Carshalton, Surrey
1870	Goodwin, James	Gas-Works, Rotherham
1869	Gore, Henry	42, Pentonville Hill, N.
1873	Graham, David Allan	Gas-Works, Middleton, Lancashire
1872	Green, Benjamin	Gas-Works, Mitcham, Surrey
1869	Green, Henry	Gas-Works, Preston, Lancashire
1876	Green, John	Gas-Works, Heckmondwike, Yorkshire
1864	Green, L. H.	
1877	Green, Robt.	Gas-Works, Carrickfergus, Ireland
1873	Greenaway, James	Gas-Works, Truro, Cornwall
1871	Greenfield, James	Hollacombe, Paignton, Torquay, Devon
*1872	Grimwood, Charles William ..	Gas-Works, Sudbury
1873	Guyatt, Thomas	41, Wool Exchange, Coleman Street, London, E.C.
*1869	Hale, John	Gas-Works, Ballymena, Ireland
1878	Halkett, Ralph	Gas-Works, Bicester, Oxon
1875	Hall, Joseph	Gas-Works, St. Helen's
1864	Hall, J. T.	Prescot, Lancashire
1873	Hamer, Thomas	Gas-Works, Chorley, Lancashire
*1874	Hamilton, J.	Gas-Works, Chertsey
1873	Hammond, John	Gas-Works, Lewes, Sussex
1864	Hammond, W. R.	Gas-Works, Deal
1877	Hammond, Wm.	Gas-Works, Hampton, Middlesex
1877	Hammond, Wm.	Gas-Works, Bognor, Sussex
*1872	Hancock, Peter	Gas-Works, Middlewich, Cheshire
1866	Hardick, Thos.	Gas-Works, Salisbury
1872	Hardie, William	Gas Office, Newcastle-on-Tyne
1869	Harding, George	Broad Green, near Liverpool
1873	Hardy, William	[don, W. 25, Acklam Road, Westbourne Park, Lon-
1873	Harkewitz, Herman	Gas Office, South Bank, Yorkshire
1877	Harper, Hy.	Gas-Works, Kensal Green, W.

	Name.	Address.
1867	Harris, Edmund H.	Gas-Works, Wallasey, Birkenhead
1871	Harris, Frederick Mole	Gas-Works, Falmouth
1869	Harris, James	Gas-Works, Ross, Herefordshire
1876	Harris, John	Gas-Woks, Plympton St. Mary, Devon
1870	Harris, Robert (*Mem. of Com.*)	Gas-Works, Bow Common, London, E.
1873	Hart, George	West Riding Asylum, Wakefield
1873	Hartley, Christopher L. ..	Gas-Works, Middleton, near Manchester
*1875	Hassall, Charles Frederick ..	Gas-Works, Whitchurch, Salop
1877	Hastings, Chas. W.	8, Buckingham Street, Adelphi, W.C.
1873	Hatch, Henry	Gas-Works, Woolton [Sydenham, S.E.
1873	Hathaway, Henry	Crystal Palace District Gas-Works, Lower
1866	Hawksley, Charles	30, Great George Street, Westminster, S.W.
1874	Hawkins, J. G.	Gas-Works, Wigan
*1872	Hegarty, John	Gas-Works, Colombo, Ceylon
1870	Helps, George	Gas-Works, Bath
1877	Henry, Thos.	Gas-Works, Ebbw Vale, Monmouthshire
*1868	Hepworth, Joseph (*Member of Committee*)	Gas-Works, Carlisle
*1868	Hersee, Alfred (*Auditor*) ..	29, Great St. Helen's, London, E.C.
1872	Hersey, Thomas	21, Abingdon Street, Westminster, S.W.
1877	Hersey, Thos. C.	Gas Office, 5, Boyne Terrace, Notting Hill, W.
1864	Hildreth, William	Colliery Offices, Darlington
1873	Hill, Henry	Gas-Works, Huyton
*1872	Hislop, George R.	Gas-Works, Paisley
1875	Hislop, Lawrence	Gas-Works, Bothwell, N.B.
1876	Hobson, John	Gas-Works, Chapel Town, near Sheffield
1865	Hodgson, James	Church Walk, Ulverston
1874	Hoile, J.	Gas-Works, Folkestone
1869	Holmes, William Cartwright	Iron-Works, Huddersfield
1873	Holmes, Thomas	Gas-Works, Pernambuco, Brazil
*1873	Howell, E.	Gas-Works, Yeovil
1875	Howitz, George	Gas-Works, Copenhagen
1877	Hudson, Geo.	Gas-Works, Santiago, Chili
*1870	Hunt, Charles (*Vice-President*)	Gas-Works, Windsor Street, Birmingham
1875	Hunt, Henry	Gas-Works, Swindon, Wilts
1866	Hunter, David	2, Cambridge Villas, South Street, Greenwich, S.E.
*1866	Hunter, James	Consumers' Gas Company, Woolwich, S.E.
*1874	Hunter, R.	Gas-Works, Stalybridge
*1869	Hunter, Samuel	Gas-Works, Salford

	Name.	Address.
1871	Hutchinson, Charles Henry ..	Gas-Works, Athens, Greece
1864	Hutchinson, John	Gas-Works, Barnsley
1867	Hutchinson, Walter W... ..	Gas-Works, Barnsley
1871	Iddon, Robert..	Gas-Works, Southport
*1866	Irons, Geo. B...	Gas-Works, Gosport
1878	Irvine, George	Gas-Works, Ripon, Yorkshire
1874	Jackson, R.	Gas-Works, Richmond, Yorkshire
1876	Jacobs, Charles	Gas-Works, Blackwater
1875	Jacques, James	Gas-Works, Stockport
1876	Jervis, John Joseph	Gas-Works, New Swindon, Wilts
1875	John, Hilary Thomas Annis..	Gas-Works, Messina, Sicily
*1868	Johnson, John..	148, Goswell Road, London, E.C.
1876	Jolliffe, John Thomas	Gas-Works, Hendon, Sunderland
1872	Jones, Charles W.	Gas-Works, Milan
1874	Jones, C. E.	Gas-Works, Chesterfield
1870	Jones, H. M. Layard	Gas-Works, Oporto
*1866	Jones, Hodgson	26, Great George Street, Westminster, S.W.
*1866	Jones, Robt. H. (*Mem. of Com.*)	Gas Offices, Dover
1874	Jones, W.	Gas-Works, Dalton-in-Furness
1872	Jones, Walter R.	Gas-Works, Monte Video
1872	Jones, William J.	Gas-Works, Malta
1870	Jowett, James..	Gas Works, Great Grimsby
1867	Kelsall, Isaac	Buckley Chambers, Ashton-under-Lyne
1875	Kelsall, James	Gas-Works, Bury, Lancashire
1873	Kemplay, Jno...	
1877	Ker, Alexander P...	Corporation Gas-Works, Adderley Street,
1876	Kershaw, Robert	Gas-Works, Calcutta [Birmingham
1876	Keys, Robert Peake	52, Clifton Street, Finsbury, London, E.C.
1871	King, Robert	10, St. Mary Axe, London, E.C.
1872	King, Robert	Stratford Road, Wolverton
1874	King, W...	Gas Office, Liverpool
*1868	Kirkham, Thos. N...	19, Abingdon Street, Westminster, S.W.
1870	Kitt, Alfred	Chartered Gas-Works, Lupus Street, Pimlico, S.W.
1874	Lacey, J...	146, Goswell Road, London, E.C.
1872	Laing, Robert..	The Limes, Upper Clapton, London, E.
1871	Lane, Denny	72, South Mall, Cork
1877	Lane, Geo.	Gas-Works, Aylesbury, Bucks
*1874	Lass, A. (*Auditor*)..	30, Gracechurch Street, London, E.C.

	Name.	Address.
1878	Latchford, Wm. J.	Gas-Works, Broadstairs, Kent
1868	Laycock, John..	Gas-Works, Keighley
1876	Layton, Thomas	Gas-Works, Redditch, Worcester
1877	Leach, Wm. T.	Gas and Water-Works, Ventnor, Isle of Wight
1878	Leather, John Petty	Gas-Works, Burnley, Lancashire
1864	Leather, S. P...	Gas-Works, Burnley, Lancashire
1866	Leslie, Frederick	Gas-Works, Moscow
*1875	Legg, H...	Gas-Works, Ossett, Yorkshire
1876	Lewis, Benjamin	Gas-Works, Caermarthen, South Wales
1878	Linging, Frederick E.	Gas-Works, Norwich
1875	Linging, Samuel Robert ..	Gas-Works, Etruria, Potteries, Staffordshire
1869	Little, Robert..	Gas-Works, Burgh, Lincolnshire
1870	Littlehales, Thomas	Gas-Works, Hamilton, Ontario, Upper Canada
1877	Littlewood, Wm.	1, Lansdowne Villas, Old Trafford, Manchester
1868	Livesay, Augustus F.	Chale, Isle of Wight
1865	Livesay, John G.	Gas-Works, Ventnor, Isle of Wight
*1873	Livesey, Frank (*Mem. of Com.*)	South Metropolitan Gas-Works, Old Kent Road, London, S.E.
*1864	Livesey, Geo. T. (*Past Pres. and Mem. of Finance Com.*)	South Metropolitan Gas-Works, Old Kent Road, London, S.E.
1866	Loam, M. H.	Gas-Works, Nottingham
*1864	Longworth, Wm.	Gas-Works, Guildford, Surrey
*1872	Lord, Edmund	Gas-Works, Whitworth, Rochdale
1866	Lowe, James	Gas-Works, Bridport
1874	Loxley, T...	Gas-Works, Church
1875	Lukey, Robert John	Gas-Works, Falmouth
1875	Lupton, James	Gas-Office, Boar Lane, Leeds
1869	Lyne, John	Gas-Works, Wexford, Ireland
1866	Lyon, Henry	Barton House, Deansgate, Manchester
1874	Lyon, J. H.	Gas-Works, Macclesfield
1876	M'Crae, John	Gas-Works, Bury St. Edmund's
1876	M'Gilchrist, James..	Gas-Works, Dumbarton
1875	Mackenzie, William	Gas-Works, Dunfermline
1874	Mann, W.	Pembroke Villa, Wellesley Road, Gunnersbury, Middlesex
*1869	M'Millan, John	Gas-Works, Stoke-on-Trent
1877	McMinn. F. A.	Gas-Works, Fulham
*1869	Macnie, John	Gas-Works, Londonderry, Ireland

	Name.	Address.
1873	Macpherson, Adam..	Gas-Works, Kirkcaldy
1873	McCrae, B. M.	Gas-Works, Dundee
1875	Malam, Abraham	Gas-Works, Dumfries
1866	Malam, Geo. Dunbar	Gas-Works, Bingley
1871	Manning, Henry	Gas-Works, Hythe, Kent
1872	Markham, Thomas T.	102, Fetter Lane, London, E.C.
*1875	Marr, Robert	Gas-Works, Sandown, Isle of Wight
1878	Marshall, F. D.	Gas-Works, Brentford, Middlesex
1869	Marsland, John	Gas-Works, Newry, Ireland
1876	Martin, Henry Robert H. ..	Gas-Works, Llanelly, South Wales
1864	Martin, John	Gas-Works, Ormskirk
1869	Martin, Michael	Gas-Works, Drogheda, Ireland
1871	Martin, Thomas Henry	Gas-Works, New Barnet
1875	Martyn, John..	Gas-Works, Wadebridge, Cornwall
*1868	May, Thomas	Gas-Works, Canterbury
1875	May, Jun., Thomas	Gas-Works, Calcutta
*1873	Mead, A.	Gas-Works, Chelmsford, Essex
1869	Mead, Charles Roper	Devon Lodge, Grove Road, Sutton, Surrey
*1874	Mead, F...	Gas-Works, Sutton, Surrey
1877	Mearns. Jas.	Gas-Works, Banbridge, Ireland
1872	Medhurst, Jun., William ..	Gas-Works, Folkestone
1871	Meiklejohn, James..	Gas-Works, Houghton-le-Spring
1869	Melling, Thomas	Gas-Works, Rainhill, Lancashire
1874	Merriman, J. D.	Gas-Works, Pictou, Nova Scotia
1870	Methven, John	Gas-Works, Nine Elms, London, S.W.
1870	Middleton, John	Gas-Works, Wandsworth, Surrey, S.W.
*1873	Mildred, M.	64, Bankside, Southwark, S.E.
1867	Miles, John	17, Market Street, Bolton, Lancashire
1867	Miles, William	Gas-Works, Clitheroe
1875	Mills, William Pitt	Gas-Works, Dartford, Kent
1874	Mitchell, H. J.	Gas-Works, Hornsey, Middlesex
1874	Monk, L..	Gas-Works, Lanark, N.B.
1875	Monson, Philip	Vestry Hall, High Street, Kensington, W.
1877	Monnier, Dimitri	57, Rue Pigalle, Paris
1865	Moon, Wm. Jas.	16, York Place, Scarborough
1869	Moor, William	Hetton Colliery, near Fence Houses
1872	Moor, William	
1877	Moore, Thos.	Gas-Works, Macclesfield
*1875	Moorhouse, Robert Kaye ..	Gas-Works, Barbadoes
*1874	Morland, R.	Gas-Works, Gloucester
1868	Morris, Joseph..	Gas-Works, Jersey

	Name.	Address.
1876	Morton, John	Gas-Works, Ashford, Kent [S.W.
*1864	Morton, Robert (*Past Pres.*)..	London Gas-Works, Nine Elms, London,
*1872	Mossman, Thomas	Gas-Works, West Hartlepool
1864	Mudie, John	Gas-Works, Burton-on-Trent
1872	Muriel, George	Gas-Works, Bahia
*1864	Murphy, A. M.	Gas-Works, Cirencester
1877	Murray, M.	Gas-Works, Bungay, Suffolk
*1875	Murray, Stephen	Gas-Works, Uttoxeter, Staffordshire
1864	Newall, Henry (*Trustee and Treasurer*)	10, Marsden Street, Manchester
1864	Newbigging, Thomas	5, Norfolk Street, Manchester
1878	Newton, Alexander	Gas-Works, Hong Kong
1874	Nicholls, J. S	Gas-Works, South Bank, Yorkshire
*1867	Niven, John	Gas-Works, Clayton, near Bradford
1870	North, William	Gas-Works, Stourbridge
1872	Ogden, Samuel Robinson ..	Gas-Works, Blackburn
*1874	Ogg, D. W.	3, Jeffery's Square, St. Mary Axe, E.C.
*1866	Ohren, John	Gas-Works, Rio de Janeiro, Brazil
*1864	Ohren, Magnus (*Past Acting President*)	Crystal Palace District Gas Company, Lower Sydenham, S.E.
1877	Oldfield, Fredk. Wm.	Gas-Works, Hull
*1870	Osborn, George Holmes	Gas-Works, Bromley, Kent
1866	Osmond, William	Gas-Works, Dorchester
*1874	Packham, H. F.	Gas-Works, Kingston-on-Thames
*1870	Padfield, William Albert ..	Gas-Office, Exe Island, Exeter
1878	Palethorpe, Wm. Walter ..	Gas-Works, Great Northern Railway, Doncaster, Yorkshire
1874	Palmer, J. E	Gas-Works, Great Malvern
1865	Parkinson, G. J.	307, Moseley Road, Birmingham
1878	Parker, George	Gas-Works, Oakengates, Salop
1873	Parks, Thomas	Gas-Works, Moscow
*1868	Parlby, William	Gas-Office, Sheffield
*1876	Parsons, James Henry	Gas-Works, Oswestry
1878	Parsons, Samuel	Gas-Works, Bury, Lancashire
*1872	Parsons, Matthew J.	Gas-Works, Carnarvon
*1872	Parsons, William	Gas-Works, Atherstone
*1864	Paterson, Jas. (*Past President*)	Gas-Works, Warrington
*1870	Paterson, Robert Ormiston (*Member of Committee*) ..	Gas-Works, Cheltenham

	Name.	Address.
1874	Paterson, T. O.	Gas-Works, Rochdale
1873	Pazzani; J.	Gas-Works, Belvedere, Vienna, Austria
1875	Peaty, Henry	Gas-Works, Longport, Staffordshire
1876	Peeks, Henry	Gas-Works, Thorne, Yorkshire
*1876	Penney, John Harper	Gas-Works, South Shields
*1869	Penny, Alfred	20, Abingdon Street, Westminster, S.W.
1874	Pepys, W. H...	Gas-Works, Ehrenfeld, Cologne
*1867	Phelps, Joseph	Gas-Works, Marlborough, Wilts
1869	Phillips, Arthur Frederick ..	Gas-Works, St. Albans
1873	Phillips, E. E.	Gas-Works, High Wycombe, Bucks
1874	Phillips, W. R.	Gas-Works, Luton, Bedfordshire
1872	Philps, Walter	High Street, Dorking, Surrey
1871	Pierson, Henry Samuel.. ..	Matilda Cottage, Chatham Road, Wandsworth Common, S.W.
*1874	Pike, E. S.	Gas-Works, Ystrad, Rhondda Valley, Glamorganshire
1869	Plumbe, William A.	Gas-Works, Sutton-in-Ashfield, Notts
1875	Porteous, William	Gas-Works, Mill Hill, Hendon, Middlesex
1869	Prescott, William	Gas-Works, Prescot, Lancashire
1868	Price, Edward..	Gas-Works, Hampton Wick, London, S.W.
*1871	Price, Robert	Gas-Works, Llandudno, North Wales
1873	Pritchard, F.	Gas-Works, Southport, Lancashire
*1875	Proud, Thomas	103, Icknield Street East, Birmingham
1869	Rafarel, William Claude ..	Gas-Works, Barnstaple, Devon
*1871	Randall, James	Gas Office, Tottenham, N.
1868	Read, Charles	Gas-Works, Red Hill
1866	Read, John	Gas Office, Tunbridge Wells
1877	Redman, Jas.	Gas-Works, Haworth
1868	Reed, Joseph	Gas-Works, Newport, Isle of Wight
*1874	Reeves, J. S.	Gas Office, Bilston
1869	Reid, John	Gas Engineer, Midland Railway, Derby
1873	Reid, John	Edinburgh and Leith Gas Co.'s Office, 8, George Street, Edinburgh
1873	Richards, William	11, St. Michael's Road, Stockwell, London, S.W.
*1874	Richmond, J.	Gas-Works, Worthing, Sussex
1876	Ridley, George	Gas-Works, Elswick, near Newcastle-on Tyne
*1875	Riley, Francis..	Gas-Works, Bishop Stortford, Herts
1873	Riley, James	Gas-Works, Brighouse
1877	Roberts, Wm. Hy.	Gas-Works, Newton Abbott, Devonshire

	Name.	Address.
1875	Roberts, William Thomas ..	Gas-Office, Altrincham, Cheshire
*1865	Robinson, Chas. R.	Gas-Works, Coventry
1866	Robinson, C. S.	Gas-Works, Leicester
1866	Robinson, Geo. A.	Gas-Works, Leicester
*1864	Robinson, W. L.	Gas-Works, Coventry
1876	Rogers, George	Gas-Works, Hexham
1869	Romans, W.	Gas Office, Commercial Street, Sheffield
*1874	Ross, R.	Gas-Works, Hiogo, Japan
*1875	Russell, Frederick	Gas-Works, Ilfracombe, North Devon
*1867	Russell, John	Gas-Works, Uxbridge
1874	Russell, W. J.	Gas-Works, Croydon, Surrey
*1876	Sainsbury, Henry	Gas-Works, Trowbridge, Wilts
1874	Sapey, E.	Gas-Works, Tamworth
1874	Saville, G. E.	Gas-Works, Sowerby Bridge
1870	Scott, George	Gas-Works, Tunbridge Wells
1874	Sellers, C.	Gas Office, York
*1875	Shaull, Edward	Gas-Works, Penrith, Cumberland
*1872	Sheppard, Robert	Gas-Works, Horsham, Sussex
1878	Sheppard, T. L.	Gas Office, Middle Street, Farnworth, near Bolton, Lancashire
1864	Shimeld, William	Gas-Works, Dundalk, Ireland
1878	Shonbridge, Sydney Yarrell ..	Gas-Works, Saltley, Birmingham
1874	Shone, C. G.	Brentford Gas-Works, Southall
1877	Sidle, Robt. John	Gas Office, Hythe, Kent
1864	Simpson, P.	Gas-Works, Rugby
1876	Singleton, Henry	Gas-Works, Dronfield, near Sheffield
1866	Smedley, Geo.	Gas-Works, Buxton, Derbyshire
1876	Smith, John	Gas-Works, Sunbury-on-Thames
*1869	Smith, Joseph Richard	Gas-Works, Padiham
1876	Smith, Robert	Gas-Works, Darlington
1870	Smith, Thomas	17, King Street, Wigan
1864	Smith, Jun., William	Gas-Works, Hyde
1875	Smith, William	Gas-Works, Darlington, Durham
1876	Smith, William	Gas-Works, Helensburgh
1866	Somerville, John	17, St. Andrew Street, Dublin
1876	Sowood, Silas	Gas-Works, Canal Basin, Gravesend
*1875	Sparke, John Budge	21, Victoria Chambers, South Parade, Leeds
*1868	Spice, Robert P. (*Past Pres.*)	21, Parliament Street, London, S.W.
*1876	Stansfield, William	Gas-Works, Drighlington

	Name.	Address.
1873	Steinacher, J. E.	Gas-Works, St. John's, Porto Rico
1871	Stelfox, Jun., James	Gas-Works, Belfast
1867	Stephenson, H. P.	10, St. Mary Axe, London, E.C.
1876	Stephen, William Henry ..	Gas-Works, Sydney, New South Wales
1867	Stevens, Frederick James ..	19, Southwark Bridge Road, London, S.E.
1873	Stevenson, G. Ernest	Gas-Works, Peterborough
*1867	Stevenson, Geo. Wilson (*Vice-Pres. & Mem. of Finance Com.*)	4, Westminster Chambers, Victoria Street, Westminster, S.W.
1873	Stevenson, John Stuart	73, Sir John Rogerson's Quay, Dublin
1877	Stevenson, Sidney Evance ..	The Basin Gas-Works, Exeter
1871	Still, Alfred H.	Gas-Works, Cork
1877	Stiven, David..	Gas-Works, St. Thomas, Dutch West Indies
*1867	Stone, Thomas	Gas-Works, Weymouth
*1865	Storer, John (*Member of Committee*)..	Gas-Works, Stafford
1872	Stormonth, Thomas	Gas-Works, St. Anne's-on-the-Sea, Lancs.
1866	Stout, William	Gas-Works, Boston
1870	Studholm, Shadrach	Gas-Works, Whitehaven
1876	Surl, James	Gas-Works, Tralee, Ireland
1872	Swallow, David	Gas-Works, Bradford
1868	Syms, William	Gas-Works, Rochester
1877	Tait, Wm.	Gas-Works, Portadown, Armagh, Ireland
1872	Tallentire, Thomas..	Gas-Works, Lurgan, Ireland
1873	Tayler, James..	Gas-Works, Fareham, Hants
1867	Taylor, Charles	Gas-Works, Derby
1874	Terdrey, C.	Gas-Works, Tavistock
1873	Thomas, Alfred	Gas-Works, Basingstoke, Hants
*1874	Thomas, J.	Gas-Works, Bodmin
*1873	Thomas, R. P.	Gas-Works, Ware, Herts.
1864	Throsby, W. P.	Gas-Works, Lincoln
1875	Timmins, Joseph	Gas-Works, Leigh, Lancashire
1869	Tindall, John	Gas-Works, Walsall
1869	Tinney, William Upton.. ..	Gas-Works, Winchester
*1876	Tobey, Henry..	Gas-Works, New Malton, Yorkshire
1876	Townsend, Harry	Gas-Works, Waltham, Essex
*1872	Travers, Thomas	Gas-Works, Cork, Ireland
1870	Trewby, George Careless ..	Gas-Works, Beckton, North Woolwich, E.
*1867	Trewhitt, Thos.	Gas-Works, West Hartlepool

	Name.	Address.
1869	Upward, Alfred	8, Queen Anne's Gate, Westminster, S.W.
*1872	Valon, William A.	Gas-Works, Ramsgate
1870	Vanheson, George B.	Gas-Works, Rochester
1869	Varley, Thomas	Gas-Works, Colne, Lancashire
1865	Veevers, Harrison	Gas-Works, Bolton
*1869	Venner, Bartholomew Gay ..	Gas-Works, Eton, Bucks
*1864	Wadeson, James	Gas-Works, Windsor
1874	Walduck, C. E.	148, Gresham House, Old Broad St., E.C.
1878	Walker, John	Gas-Works, County Asylum, Colony Hatch
1877	Walker, Thos.	Gas-Works, Wrexham
*1875	Walker, William Arthur ..	Gas-Works, Elland, Yorkshire
1874	Walton, Thomas	Gas-Works, Shrewsbury
1866	Warner, W. J. (*President*) ..	Gas-Works, South Shields
1871	Warsop, Henry	Gas-Works, East Croft, Nottingham
*1873	Waters, G. R.	The Grove, Portland
*1866	Wates, Percy J.	Phœnix Gas-Works, Greenwich, S.E.
1876	Watson, John Kippen	Edinburgh Gaslight Company's Office, 25, Waterloo Place, Edinburgh
1872	Watson, James	Gas-Works, Herne Bay
1876	Watson, Samuel	Gas-Works, Tunstall, Staffordshire
*1875	Watson, William	Gas-Works, Effingham Street, Sheffield
1877	Webb, Thos.	Gas-Works, Egham
1872	Wells, Henry F.	Gas-Works, Tredegar, Monmouthshire
*1869	West, John	Gas-Works, Maidstone
1875	Whitaker, John William ..	Gas-Works, Wakefield, Yorkshire
1871	Whitaker, William Butler ..	Gas-Works, Buenos Ayres
1877	White, Chas.	Gas-Works, Blaenavon
1868	White, T. W. R.	Gas-Works, Sherborne
*1872	White, William	Equitable Gas-Works, Woolwich, S.E.
1872	White, William	Gas-Works, Abersychan, near Pontypool, Monmouthshire
1875	Whitehead, John	Gas-Works, Dronfield, near Sheffield
1871	Whitehead, Wm. Swallow ..	11, Drewton Street, Bradford
1874	Whyte, J.	Gas-Works, Seaham Harbour
1877	Whyte, Peter	Gas-Works, Bute Docks, Cardiff
1869	Wilkinson, Peter Haines ..	Gas Office, James Street, Harrogate
1873	Wilkinson, Thomas	Gas-Works, Newmarket, Suffolk
1868	Williams, Alfred	64, Bankside, London, S.E.
1864	Willis, W. H.	Gas-Works, Great Yarmouth

	Name.	Address.
1878	Wilshaw, W. G.	8, Clemence Street, Burdett Road, Limehouse, London, E.
1874	Wilson, A. F...	34, St. George's Road, Southwark, London,
1878	Wilson, Robert	Gas-Works, Croydon, Surrey [S.E.
1870	Wilson, William Purvis ..	220, Malpas Road, New Cross, London, S.E.
1871	Wilton, John	Gas-Works, Silvertown, North Woolwich, E.
*1876	Wimhurst, Harry	Gas-Works, Andover
*1875	Winstanley, George	Gas-Works, Coventry, Warwickshire
1875	Winstanley, William	Gas-Works, Newcastle-under-Lyme, Staffordshire
*1865	Wood, Alfred H. (*Mem. of Com.*)	Gas-Works, Hastings
1866	Wood, William	Gas-Works, Birkenhead
1878	Wood, William	Gas-Works, Colnbrook
*1865	Woodall, Corbet (*Past Pres.*)..	Phœnix Gas-Works, Vauxhall, London,
1865	Woodall, Henry	Gas Office, Leeds [S.W.
1876	Woodruff, William Wells ..	Gas-Works, Sandwich
1872	Woodward, John	Gas-Works, Spalding, Lincolnshire
1870	Wright, Charles	Gas-Works, Saffron Walden, Essex
1875	Wright, George	Gas-Works, Redcar, Yorkshire
*1864	Wright, William	Alexandra Road, Shipley, near Leeds
*1868	Wright, William	Gas-Works, Black Rock, Brighton
1878	Yates, Ernest	Gas-Works, Shaftesbury, Dorsetshire

(*Number of Ordinary Members*, 594.)

Extra-Ordinary Members.

	Name.	Address.
*1868	Aird, John	Belvedere Road, Lambeth, London, S.E.
*1872	Aird, Joseph	Wellington Tube-Works, Great Bridge, Tipton
1872	Andrews, William Ward ..	Gas-Meter Company's Works, 238, Kingsland Road, London, E.
1873	Ashmore, William	Hope Iron-Works, Stockton-on-Tees
1874	Bowlay, H.	Gasholder Works, Spring Hill, Birmingham
1878	Booth, Jas.	Hazelhurst, Turton, Lancashire
1872	Braddock, Joseph	Globe Meter-Works, Wellington Street, Oldham

	Name.	Address.
1877	Calvert, John	Colliery Proprietor, Pontypridd, Glamorganshire
1878	Chandler, Josiah	104, Newington Causeway, London, S.E.
1878	Chandler, Samuel	104, Newington Causeway, London, S.E.
1875	Cockey, Francis Christopher..	Iron-Works, Frome Selwood, Somerset
1874	Colyer, F.	Phœnix Engineering Works, Holland Street, Southwark, S.E.
1877	Corbett, Wm.	Retort Manufacturer, Stourbridge
1873	Cowan, William	Buccleuch Street Works, Edinburgh
1868	Cowen, John A.	Blaydon-on-Tyne
*1869	Cutler, Samuel	Providence Iron-Works, Millwall, Lond., E.
1878	Davies, Ferrand	148, Gresham House, Old Broad Street, London, E.C.
1878	Davis, Geo. E.	87, Barton Arcade, Manchester
1877	Dempster, John	Gas Engineer, Rose Mount, Elland
1877	Dempster, Jun., Robert ..	Gas Engineer, Rose Mount, Elland
1870	Donaldson, A.	Buccleuch Street Works, Edinburgh
1876	Gibbons, Jun., Benjamin ..	Dibdale Retort-Works, Stourbridge
1877	Hallsworth, Samuel	Copperas Manufacturer, Armley, Leeds
1874	Harvey, W.	Lairn Works, Plymouth
1874	Holman, S.	10, Laurence Pountney Lane, E.C.
*1870	Horsley, Charles	21, Wharf Road, City Road, London, N.
1875	Kelly, Richard Roper	59, Mark Lane, London, E.C.
1871	Laidlaw, David	Gas Engineer, Glasgow
1874	Lloyd, G. H.	Gasholder Works, Spring Hill, Birmingham
1877	Lockwood, Thomas	Colliery Proprietor, Stalybridge
*1875	Mackay, Alexander	Grange Works, Edinburgh
1872	M'Dougall, James Thomas ..	10, Mark Lane, London, E.C.
1872	M'Dougall, Jun., Alexander..	68, Port Street, Manchester
1872	Manwaring, Joseph	101, Cannon Street, London, E.C.
1874	Murphy, D.	Garratt Street Works, Oldham Road, Manchester
1875	Newton, Robert	Union Street, Oldham
1871	O'Neill, John W.	161, Palmerston Buildings, London, E.C.
1876	Orme, Daniel	Gas-Meter Works, Park Street, Oldham

	Name.	Address.
*1872	Peebles, D. Bruce	Tay Works, Bonnington, Edinburgh
1866	Potter, Addison	Willington Quay, near Newcastle-upon-Tyne
1876	Potter, Charles John	Retort Manufacturer, Newcastle-on-Tyne
1878	Richardson, William	Hebburn Colliery, 29, Quay Side, Newcastle-on-Tyne
1874	Sadler, S. A.	Middlesborough
1875	Steuart, David Vincent.. ..	Albert Chemical Works, Bradford, near Manchester
1878	Stephenson, Andrew	The Gas Purification and Chemical Company, 161, Palmerston Buildings, London, E.C.
1875	Thomas, Henry	Falcon Street, Oldham
1870	Thorneloe, George	57, Barbican, London, E.C.
*1873	Thorns, Abraham	Farnley, near Leeds
1874	Varley, W. H.	Parliament Street, Colne
*1868	Walker, William Thomas ..	Donnington, near Newport, Salop, and 8, Finsbury Circus, London, E.C.
1878	Wallace, R. W.	Manufacturing Chemist, 60, Mark Lane, London
*1870	Waller, George	Phœnix Engineering Works, Holland Street, Southwark, London, S.E.
1872	Willey, Henry Frederick ..	4, Longbrook Street, Exeter
1878	Woodward, John	Engineer, Manchester
1877	Wright, John	Essex Works, Broad Street, Birmingham
1877	Wrigley, E. G.	Colliery Proprietor, 120A, Stamford Street, Ashton-under-Lyne
1876	Wyld, John	Messrs. Spence Brothers' Chemical Company, Limited, Bradford, Manchester
1878	Young, John Richard	3, Abbotsford Terrace, Moor Edge, Newcastle-on-Tyne

(*Number of Extra-Ordinary Members*, 58.)

Total number of Members, 666.

LIST OF MEMBERS.

Arranged in the Alphabetical Order of the Towns they reside in.

A * prefixed to the name denotes an Honorary Member.
A † „ „ Extra-Ordinary Member.

ABERGAVENNY, Mon.	Samuel Cross, Gas-Works.
ABERSYCHAN, Mon.	William White, Gas-Works.
ABERYSTWITH, Cardiganshire	James Dougall, Gas-Works.
ABINGDON, Berks	S. Ely, Gas-Works.
ALDERSHOT	Thomas Douglas, Cross House.
ALFRETON, Derbyshire	S. Alsop, Gas-Works, Pool Close, Pinxton.
ALTON, Hants	Frederick Barnley, Gas-Works.
ALTRINCHAM, Cheshire	William Thomas Roberts, Gas Offices.
ANDOVER, Hampshire	Harry Wimhurst, Gas-Works.
ARMLEY, near Leeds, Yorkshire ..	†Samuel Hallsworth.
ARUNDEL, Sussex	W. C. Dawson, Gas-Works.
ASHFORD, Kent	John Morton, Gas-Works.
„ „	George Berry.
ASHTON-UNDER-LYNE, Lancashire ..	Isaac Kelsall, Buckley Chambers.
„ „ „ ..	David Clarke, Gas-Works.
„ „ „ ..	†E. G. Wrigley, 120A, Stamford Street.
ATHENS, Greece	Charles Henry Hutchinson, Gas-Works.
ATHERSTONE, Warwickshire	William Parsons, Gas-Works.
AYLESBURY, Bucks	George Lane, Gas-Works.
BACUP, Lancashire	William Blackledge, Gas-Works.
BAHIA, Brazil	George Muriel, Gas-Works.
BALDOCK, Herts	James Gilbert Dear, Gas-Works.
BALLYMENA, Co. Antrim, Ireland ..	John Hale, Gas-Works.
BANBRIDGE, County Down	James Mearns, Gas-Works.
BANBURY, Oxon	W. R. Cooper, Gas-Works.
BARBADOES, West Indies	Robt. Kaye Moorhouse, Gas-Works.
BARCELONA, Spain	Claudio Gil, Gas-Works.
BARNSLEY, Yorkshire	John Hutchinson, Gas-Works.

Barnsley, Yorkshire	Walter W. Hutchinson, Gas-Works.
Barnstaple, Devon..	William Claude Rafarel, Gas-Works.
Barrow-in-Furness	A. C. Fraser, Gas-Works.
Basingstoke, Hants	Alfred Thomas, Gas-Works.
Bath	George Helps, Gas-Works.
„	Thomas Anderson, Gas-Works.
Batley, Yorkshire	C. Eastwood, Gas-Works.
Beckton, North Woolwich	George Careless Trewby, Gas-Works.
„ „	Frederick Beale, Gas-Works.
Belfast, Co. Antrim, Ireland ..	James Stelfox, jun.
„ „ „ ..	Andrew Gibb, Gas-Works, Ormeau Road.
Beverley, Yorkshire	Eli Bryan, Gas-Works.
Bicester, Oxon..	Ralph Halkett, Gas-Works.
Bilston, Staffordshire	J. S. Reeves, Gas Office.
Bingley, Yorkshire..	Geo. Dunbar Malam, Gas-Works.
Birkenhead	William Wood, Gas-Works.
Birmingham	Charles Hunt (*Vice-President*), Gas-Works, Windsor Street.
„	G. J. Parkinson, 307, Moseley Road.
„	†H. Bewlay, Gasholder Works, Spring Hill.
„	†G. H. Lloyd do. do.
„	Thomas Proud, 103, Icknield Street East.
„	Alfred Colson, Gas-Works, Windsor Street.
„	*William Richardson, 62, Pershore Road, Edgbaston.
„	Alexander Poutey Kerr, Gas-Works, Adderley Street.
„	†John Wright, Essex Works, Broad Street.
„	Sidney Yarrell Shonbridge Gas-Works, Fazeley Street.
„	Geo. J. Davis, Gas-Works, Fazeley Street.
Bishop's Stortford, Herts	Francis Riley, Gas-Works.
Blackburn, Lancashire	S. R. Ogden, Gas-Works.
„ „	Francis William Brothers, 6, Mill Lane.
Blackwater, Surrey	Charles Jacobs, Gas-Works.
Blaenavon, Mon.	Charles White, Gas-Works.
Blaydon-on-Tyne	†John A. Cowen.
Blyth, Northumberland	James Eadington, Gas-Works.
Bodmin, Cornwall	J. Thomas, Gas-Works.
Bognor, Sussex	William Hammond, Gas-Works.
Bolton, Lancashire	Harrison Veevers, Gas-Works.
„ „	John Miles, 17, Market Street.

Boston, Lincolnshire	William Stout, Gas-Works.
Boston, Mass., United States	William Eliot Fette, 11, Walnut Street.
Bothwell, N.B.	Lawrence Hislop, Gas-Works.
Bournemouth, Hants	George Gooch, Gas and Water Co.'s Office.
,, ,, ...	John Wilson, Gas and Water Office.
,, ,, ...	Robt. Darney, Jun., Gas and Water Works.
Bradford, near Manchester	†John Wyld, Spence Brothers' Chemical Company, Limited.
Bradford, Yorkshire	David Swallow, Gas-Works.
,, ,, ...	William Swallow Whitehead, 11, Drewton Street.
Bradley Green, near Congleton ..	G. S. Furnivall, Gas-Works.
Brentford, Middlesex	F. J. Evans, Clay Ponds.
,, ,, ...	F. D. Marshall, Gas-Works.
Bridgnorth, Salop	Joshua Gill, Gas-Works.
Bridgwater, Somerset	James Hughes Cornish, Gas-Works.
Bridport, Dorsetshire	James Lowe, Gas-Works.
Brighouse, York	J. Riley, Gas-Works.
Brighton, Sussex	William Wright, Gas-Works, Black Rock.
Bristol	Walter Fiddes, Gas-Works.
Broad Green, near Liverpool ..	George Harding.
Broadstairs, Kent	Wm. J. Latchford, Gas-Works.
Bromley, Kent	George Holmes Osborne, Gas-Works.
Bucharest, Turkey	Robert Fish, Gas-Works.
Buenos Ayres	William Butler Whitaker, Gas-Works.
Bungay, Suffolk	Matthew Murray, Gas-Works.
Burgh, Lincolnshire	Robert Little, Gas-Works.
Burnley, Lancashire	S. P. Leather, Gas-Works.
,, ,, ...	John Petty Leather, Gas-Works.
Burton-on-Trent, Staffordshire ..	John Mudie, Gas-Works.
Bury, Lancashire	James Kelsall, Gas-Works.
,, ,, ...	Saml. Parsons, Gas-Works.
Bury St. Edmund's, Suffolk	John McCrae, Gas-Works.
Buxton, Derbyshire	Geo. Smedley, Gas-Works.
Caermarthen, South Wales	Benjamin Lewis, Gas-Works.
Calcutta	*James Blackburn, Gas-Works.
,, ...	Thomas May, Gas-Works.
,, ...	Robert Kershaw, Gas-Works,
Camborne, Cornwall	William Bailey, Gas-Works.
Canterbury, Kent	Thomas May, Gas-Works.
Cardiff, Glamorganshire	Henry Bowen, Gas-Works.

Cardiff, Glamorganshire	Peter Whyte, Bute Gas-Works.
Carlisle, Cumberland	Joseph Hepworth (*Mem. of Com.*), Gas-Works.
Carnarvon	Matthew J. Parsons, Gas-Works.
Carrickfergus, County Antrim ..	Robert Green, Gas-Works.
Carshalton, Surrey	Robert Good, Gas-Works.
„ „	Joseph Mellen Bickford, Gas-Works.
Chale, Isle of Wight	Augustus F. Livesay.
Chapel Town, near Sheffield.. ..	John Hobson, Gas-Works.
Chelmsford, Essex	A. Mead, Gas-Works.
Cheltenham, Gloucestershire ..	Robert Ormiston Paterson (*Mem. of Com.*), Gas-Works.
„ „	J. A. Coombs, Gas-Works.
Chepstow, Monmouthshire	William Dore, Gas-Works.
Chertsey, Surrey	J. Hamilton, Gas-Works.
Chesterfield, Derbyshire	C. E. Jones, Gas-Works.
Chichester, Sussex	Robert Church, Gas-Works.
Chorley, Lancashire	Thomas Hamer, Gas-Works.
Christchurch, Canterbury, New Zealand	Thos. Stanley Cleminshaw, Gas-Works.
Church, Lancashire..	T. Loxley, Gas-Works.
Cirencester, Gloucestershire.. ..	A. M. Murphy, Gas-Works.
Clayton, near Bradford	John Niven, Gas-Works.
Cleethorpes, Lincolnshire	A. Downie, Gas-Works.
Clevedon, Somerset	Samuel Dawes, Gas-Works.
Clitheroe, Lancashire	William Miles, Gas-Works.
Colchester, Essex	J. T. Browning, Gas-Works.
Colne, Lancashire	Thomas Varley, Gas-Works.
„ „	†W. H. Varley, Parliament Street.
Colney Hatch..	John Walker, Gas-Works, County Asylum.
Colnbrook	Wm. Wood, Gas-Works.
Cologne	W. H. Pepys, Gas-Works, Ehrenfeld.
Colombo, Ceylon	John Hegarty, Gas-Works.
Copenhagen, Denmark	George Howitz, Gas-Works.
Cork, Ireland	Denny Lane, 72, South Mall.
„ „	A. H. Still, Gas-Works.
„ „	Thomas Travers, Gas-Works.
Coventry, Warwickshire	Chas. R. Robinson, Gas-Works.
„ „	W. L. Robinson, Gas-Works.
„ „	George Winstanley, Gas-Works.
Cowes, Isle of Wight	Thomas Giles, Gas-Works.
Crayford, Kent	William W. Box, Gas-Works.
Crewe, Cheshire	Wm. Davison, Gas-Works.

Croydon, Surrey	W. J. Russell, Gas-Works.
,, ,, ...	Robert Wilson, Gas-Works.
,, ,, ...	Charles Farrand, Gas-Works.
Dalton-in-Furness, Lancashire ..	W. Jones, Gas-Works.
Darlington, Durham	William Smith, Gas-Works.
,, ,, ...	William Hildreth, Colliery Offices.
,, ,, ...	Robert Smith, Gas-Works.
Dartford, Kent	L. H. Green.
,, ,, ...	William Pitt Mills, Gas-Works.
Darwen	Thomas Duxbury, Gas-Works.
Deal, Kent	W. R. Hammond, Gas-Works.
Denby Dale, near Huddersfield ..	John Forbes.
Derby	John Reid, Gas Engineer, Midland Railway.
,, ...	Charles Taylor, Gas-Works,
,, ...	James B. Coulson, 92, Friar Gate.
Dewsbury, Yorkshire	Charles Armitage, Gas-Works.
Doncaster, Yorkshire	R. Bridge, The Plant.
,, ,, ...	Wm. Walter Palethorpe, Gas-Works.
Dorchester	William Osmond, Gas-Works.
Dorking, Surrey	Walter Philps, High Street.
Dover, Kent	R. H. Jones (*Mem. of Com.*), Gas-Works.
,, ,, ...	John Donaldson, Gas-Works.
Drighlington, Yorkshire	William Stansfield, Gas-Works.
Drogheda, Ireland	Michael Martin, Gas-Works.
Dronfield, near Sheffield	John Whitehead, Gas-Works.
,, ,, ...	Henry Singleton, Gas-Works.
Dublin	John Somerville, 17, St. Andrew Street.
,, ...	J. Stuart Stevenson, 73, Sir John Rogerson's Quay.
,, ...	William Daniel, *55*, Mary Street.
Dumbarton, N.B.	James McGilchrist, Gas-Works.
Dukinfield, Cheshire	William Bridge, Gas-Works.
Dumfries	Abraham Malam, Gas-Works.
Dundalk, Co. Louth, Ireland ..	William Shimeld, Gas-Works.
Dundee, Forfar	B. M. McCrae, Gas-Works.
Dunedin, New Zealand	E. Genever, Gas-Works.
Dunfermline, N.B.	William Mackenzie, Gas-Works.
Ebbw Vale, Monmouthshire	Thomas Henry, Gas-Works.
Edinburgh	†A. Donaldson, Buccleuch Street Works.

EDINBURGH—*continued*	†Alexander Mackay, Grange Works.
,, ...	*Dr. Stevenson Macadam, Surgeon's Hall.
,, ...	†D. Bruce Peebles, Tay Works, Bonnington.
,, ...	J. Reid, Edinburgh and Leith Gas Company's Office, 8, George Street.
,, ...	John Kippen Watson, Edinburgh Gaslight Company's Office, 25, Waterloo Place.
,, ...	†William Cowan, Buccleuch Street Works.
EGHAM, Surrey..	Thomas Webb, Gas-Works.
ELLAND, Yorkshire	R. Dempster, Gas Engineer.
,, ,, ...	William Arthur Walker, Gas Office.
,, ,, ...	†Robert Dempster, jun.
,, ,, ...	†John Dempster, Rose Mount.
ELSWICK, near Newcastle-on-Tyne .	George Ridley, Gas-Works.
ELY, Cambridgeshire	W. Hardy, Gas-Works.
EMSWORTH, Hants	R. Douglas, West Grove House.
ETON, Bucks	Bartholomew Gay Venner, Gas-Works.
ETRURIA, POTTERIES, N. Staffordshire	Samuel Robert Linging, Gas-Works.
EXETER, Devon..	Sidney Evance Stevenson, Basin Gas-Works
,, ,, ...	Thomas Dand, Linden Vale, St. David's.
,, ,, ...	William Albert Padfield, Gas Office, Exe Island.
,, ,, ...	†Henry Frederick Willey, 4, Longbrook St.
FAIRFORD, Gloucester	John Brown, Gas-Works.
FALMOUTH, Cornwall	Frederick Mole Harris, Gas-Works.
,, ,, ...	Robert John Lukey, Gas-Works.
FAREHAM, Hants.	James Tayler, Gas-Works.
FARNLEY, near Leeds, Yorkshire ..	†A. Thorns.
FARNWORTH nr. Bolton, Lancashire	T. L. Sheppard, Gas Office.
FAVERSHAM, Kent	Robert Darney, Gas-Works.
FENCE HOUSES, Durham	William Moor, Hetton Colliery.
FERMOY, Co. Cork	E. Barnett, Barrack Gas-Works.
FOLKESTONE, Kent	William Medhurst, jun., Gas-Works.
,, ,, ...	J. Hoile, Gas-Works.
FROME, Somerset	Henry Cockey, Gas-Works.
,, ,, ...	†Francis Christopher Cockey, Iron-Works.
GLASGOW	H. Bartholomew, Glenorchard, near Glasgow.
,, ...	Wm. Foulis, Gas Office, 42, Virginia Street.
,, ...	†David Laidlaw, Gas Engineer.

Glossop, Derbyshire	James Dalgliesh, Gas-Works.
Gloucester	R. Morland, Gas-Works.
Goole, Yorkshire	George Bickerton, Gas-Works.
Gosport, Hants	Geo. B. Irons, Gas-Works.
Grantham	William Barratt, Gas-Works.
Gravesend, Kent	Silas Sowood, Gas-Works, Canal Basin.
Great Bridge, near Tipton	†Joseph Aird, Wellington Tube-Works.
Great Grimsby, Lincolnshire ..	M. Broadhead.
,, ,, ...	James Jowett, Gas-Works.
,, ,, ...	J. Broadhead, Gas-Works.
Great Malvern, Worcestershire..	J. E. Palmer, Gas-Works.
Great Yarmouth, Norfolk	W. H. Willis, Gas-Works.
Greenwich, Kent	David Hunter, 2, Cambridge Villas, South Street, S.E.
,, ,, ...	Percy J. Wates, Phœnix Gas-Works.
Guernsey	Thomas C. Crossley, Gas-Works.
Guildford, Surrey	Wm. Longworth, Gas-Works.
Halifax, Yorkshire..	William Carr (*Mem. of Com.*), Gas-Works.
Hamilton, Ontario, Upper Canada .	Thomas Littlehales, Gas-Works.
,, ,, ,, ,,	E. S. Cathels.
Hamilton, N.B.	William Dunlop, Gas-Works.
Hampton, Middlesex	William Hammond, Gas Office.
Hampton Wick, Middlesex	Edward Price, Gas-Works.
Harrogate, Yorkshire	Peter Haines Wilkinson, Gas Office, James Street.
Harrow, Middlesex	J. L. Chapman, Gas-Works.
,, ,, ...	John Chapman, Gas-Works.
Harwich, Essex	Charles Broadberry, Gas-Works.
Hastings, Sussex	A. H. Wood (*Member of Committee*), Gas-Works.
Haworth, Yorkshire	James Redman, Gas-Works.
Hazelhurst, Turton, Lancashire ..	†Jas. Booth, Gas-Works.
Hebden Bridge, Yorkshire	John Uttley Blackburn, Gas-Works.
Heckmondwike, Yorkshire	Thomas Green, Gas-Works.
,, ,, ...	John Green, Gas-Works.
Helensburgh, Dumbartonshire ..	William Smith, Gas-Works.
Hendon, Middlesex	William Porteous, Gas-Works, Mill Hill.
Hendon, Sunderland	John Thomas Jolliffe, Gas-Works.
Hereford	William Davis, Gas-Works.
Herne Bay, Kent	James Watson, Gas-Works.
Hertford	Robert William Brett, Gas-Works

Hexham, Northumberland	George Rogers, Gas-Works.
High Wycombe, Bucks	E. E. Phillips, Gas-Works.
Hiogo, Japan	R. Ross, Gas-Works.
Holywood, Ireland	G. Drimmie, Gas-Works.
Hong Kong, China	Alexander Newton, Gas-Works.
Horncastle, Lincolnshire	Charles Dixon, Gas-Works.
Hornsey, Middlesex	H. J. Mitchell, Gas-Works.
Horsham, Sussex	Robert Sheppard, Gas-Works.
Houghton-le-Spring, Durham ..	James Meiklejohn, Gas-Works.
Huddersfield, Yorkshire	John Burgess, Gas-Works.
,, ,, ...	William Cartwright Holmes, Iron-Works.
,, ,, ...	Francis J. Burgess, Gas-Works.
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Huyton, Lancashire	H. Hill, Gas-Works.
Hyde, Cheshire	William Smith, jun., Gas-Works.
Hythe, Kent	Henry Manning, Gas-Works.
,, ,, ...	Robert John Sidle, Gas Office.
,, ,, ...	Geo. Culver, Gas-Works.
Ilfracombe, North Devon	Frederick Russell, Gas-Works.
,, ,, ...	F. R. Child, Gas-Works.
Invercargill, Southland, New Zealand	Wm. Daley, Gas-Works.
Ipswich, Suffolk	E. Goddard (*Trustee and Past President*), Gas-Works.
,, ,, ...	D. Ford Goddard, Gas-Works.
Jersey	Joseph Morris, Gas-Works.
Keighley, Yorkshire	John Laycock, Gas-Works.
Kidderminster, Worcestershire ..	Archibald Dougall, Gas-Works.
Kidsgrove, Staffordshire	John Davis, Gas-Works.
Kildwick, W.R. Yorkshire	John Garlick, Gas-Works.
Kilkenny	William Henry Catlin, Gas-Works.
King's Lynn, Norfolk	Arthur Graham Dow, Gas-Works.
Kingston-upon-Hull, Yorkshire ..	Andrew Dougall, Gas-Works.
Kingston-upon-Thames, Surrey ..	H. F. Packham, Gas-Works.
Kirkcaldy, Fife.	A. Macpherson, Gas-Works.
Lanark, N.B.	L. Monk, Gas-Works.
Lancaster	W. Fleming, Gas-Works.
Leamington, Warwickshire	William Cross, Gas-Works.

Leeds, Yorkshire	John Arnott, 53, Belle Vue Road.
,, ,, ...	Henry Woodall, Gas Office.
,, ,, ...	John Budge Sparke, 21, Victoria Chambers, South Parade.
,, ,, ...	James Lupton, Gas Office, Boar Lane.
,, ,, ...	Isaac Carr, 10, Crown Point Row, Hunslet.
Leicester	George A. Robinson, Gas-Works.
,, ...	C. S. Robinson, Gas-Works.
,, ...	George Goldsmith, Gas-Works.
Leigh, Lancashire	Joseph Timmins, Gas-Works.
Lewes, Sussex	John Hammond, Gas-Works.
Lincoln	W. P. Throsby, Gas-Works.
Lisburn, Co. Antrim, Ireland ..	Thomas Tallentire, Gas-Works.
Littleborough, Nottinghamshire ..	John Cockcroft, Gas-Works.
Liverpool	William King, Gas Office.
,, ...	William Cleland, Gas-Works, Linacre
Llandudno, North Wales	Robert Price, Gas-Works.
Llanelly, South Wales	Henry Robert H. Martin, Gas-Works.
London	†Aird, John, Belvedere Road, Lambeth, S.E.
,, ...	Anderson, George, 25A, Great George Street, Westminster, S.W.
,, ...	†Andrews, William Ward, Gas-Meter Co.'s Works, 238, Kingsland Road, E.
,, ...	Backler, H. McL., European Gas Office, 11, Austin Friars, E.C.
,, ...	Bailey, G. Daniel, Gas-Works, Kensal Green, W.
,, ...	Billows, H. B., 29, Camden Road, N.W.
,, ...	Botley, Charles Edward, West London Junction Gas-Works, Wormwood Scrubs, W.
,, ...	Braidwood, J. F., Phœnix Gas-Works, Bridge Foot, Vauxhall, S.W.
,, ...	Brothers, Horatio, Gas-Works, Kensal Green, W. [Common, E.
,, ...	Carpenter, Stephen, Gas-Works, Bow
,, ...	†Chandler, Josiah, 104, Newington Causeway, S.E.
,, ...	†Chandler, Saml., 104, Newington Causeway, S.E.
.. ..	Chester, William Reginald, Gas-Works, Greenwich, S.E.

LONDON—*continued* .. .. Church, G. F., *5*, Wilmington Square, W.C.
" .. .. Church, J., 17B, Great George Street, Westminster, S.W.
" .. .. Clark, Henry, Gas-Works, Great Cambridge Street, Hackney Road, E.
" .. .. Clark, John, Gas-Works, King's Cross, N.
" .. .. †Colyer, F., Phœnix Engineering Works, Holland Street, Southwark, S.E.
" .. .. Croll, Col. Alexander Angus (*Past Pres.*), 41, Wool Exchange, Coleman Street, E.C.
" .. .. Crookenden, Isaac Adolphus, Phœnix Gas Office, 70, Bankside, S.E.
" .. .. †Cutler, Samuel, Providence Iron-Works Millwall, E.
" .. .. †Davies, Ferrand, 143, Gresham House, Old Broad Street, E.C. [Westminster, S.W.
" .. .. Donaldson, Geo., 35A, Gt. George Street,
" .. .. Dozell, Hy., 11, Austin Friars, E.C.
" .. .. Earle, Norwood, 80, Cannon Street, E.C.
" .. .. Farrand, F. F., *5*, Falfield Terrace, Shakespeare Road, Acton, W.
" .. .. Gandon, Charles, Crystal Palace District Gas-Works, Lower Sydenham, S.E.
" .. .. *Glaisher, James, Blackheath, S.E.
" .. .. Gore, H., 42, Pentonville Hill, N.
" .. .. Guyatt, T., 41, Wool Exchange, Coleman Street, E.C.
" .. .. Harper, Henry, Gas-Works, Kensal Green, W.
" .. .. Harris, Robt. (*Mem. of Com.*), Gas-Works, Bow Common, E.
" .. .. *Hartley, Frederick W., 55A, Millbank Street, Westminster.
" .. .. Hastings, Charles W., 8, Buckingham Street, Adelphi, W.C.
" .. .. Hathaway, H., Crystal Palace District Gas-Works, Lower Sydenham, S.E.
" .. .. *Hawksley, Thomas (*Trustee and Past Pres.*), 30, Gt. George St., Westminster, S.W.
" .. .. Hawksley, Charles, 30, Gt. George Street, Westminster, S.W.
" .. .. Hersee, Alfred (*Auditor*), Oriental Gas Company's Office, 29, Great St. Helen's, E.C.

LONDON—*continued* .. .. Hersey, T., 19, Abingdon St., Westminster.
„ .. .. Hersey, Thos. C., Gas Office, *5*, Boyne Terrace, Notting Hill, W. [E.C.
„ .. .. †Holman, S., 10, Laurence Pountney Lane,
„ .. .. †Horsley, Charles, 21, Wharf Road, City Road, N.
„ .. .. Johnson, John, Gas Company's Office, 148, Goswell Road, E.C.
„ .. .. Jones, Hodgson, 26, Great George Street, Westminster, S.W.
„ .. .. †Kelly, Richard Roper, *59*, Mark Lane.
„ .. .. Keys, Robert Peake, *52*, Clifton Street, Finsbury, E.C.
„ .. .. King, Robert, 10, St. Mary Axe, E.C.
„ .. .. Kirkham, T. N., 19, Abingdon Street, Westminster, S.W.
„ .. .. Kitt, Alfred, Gas-Works, Lupus Street, Pimlico, S.W. [E.C.
„ .. .. Lacey, J., Gas Office, 146, Goswell Road,
„ .. .. Laing, Robert, The Limes, Upper Clapton, E.
„ .. .. Lass, A. (*Auditor*), 30, Gracechurch Street, E.C.
„ .. .. Livesey, George T. (*Past Pres. and Mem. of Finance Com.*), South Metropolitan Gas-Works, Old Kent Road, S.E.
„ .. .. Livesey, F. (*Mem. of Com.*), South Metropolitan Gas-Works, Old Kent Road, S.E.
„ .. .. Mann, Wm., Pembroke Villa, Wellesley Road, Gunnersbury.
„ .. .. †Manwaring, Joseph, 101, Cannon Street, E.C.
„ .. .. Markham, T. T., 102, Fetter Lane, E.C.
„ .. .. †McDougall, James Thomas, 10, Mark Lane, E.C.
„ .. .. McMinn, F. J., Gas-Works, Fulham, S.W.
„ .. .. Methven, John, London Gas Company's Works, Nine Elms, S.W.
„ .. .. Mildred, M., 64, Bankside, S.E.
„ .. .. Monson, Philip, Vestry Hall, High Street, Kensington, W.
„ .. .. Morton, Robt. (*Past President*), London Gas Company's Works, Nine Elms, S.W.

LONDON—*continued* .. .. †O'Neill, John W., 161, Palmerston Buildings, E.C. [Axe, E.C.

,, ... Ogg, D. W., 3, Jeffery's Square, St. Mary

,, ... Ohren, Magnus (*Past Acting President*), Crystal Palace District Gas Co.'s Works, Lower Sydenham, S.E. [minster, S.W.

,, ... Penny, Alfred, 20, Abingdon Street, West-

,, ... Pierson, Henry Samuel, Matilda Cottage, Chatham Rd., Wandsworth Common, S.W.

,, ... Richards, W., 11, St. Michael's Road, Stockwell, S.W.

,, ... Spice, R. P. (*Past President*), 21, Parliament Street, Westminster, S.W.

,, ... †Stephenson, Andrew, 161, Palmerston Buildings, E.C.

,, ... Stephenson, H. P., 10., St. Mary Axe, E.C.

,, ... Stevens, Frederick James, 18, Southwark Bridge Road, S.E.

,, ... Stevenson, Geo. Wilson (*Vice-Pres. & Mem. of Finance Com.*), 4, Westminster Chambers, Victoria Street, Westminster, S.W.

,, ... *Sugg, Wm. T., Vincent Works, Vincent Street, Westminster, S.W.

,, ... †Thorneloe, George, 57, Barbican, E.C.

,, ... Upward, Alfred, 8, Queen Anne's Gate, Westminster, S.W.

,, ... Walduck, C. E., 148, Gresham House, Old Broad Street, E.C. [Circus, E.C.

,, ... †Walker, William Thomas, 8, Finsbury

,, ... †Wallace, R. W., Mark Lane.

,, ... †Waller, George, Phœnix Engineering Works, Holland Street, Southwark, S.E.

,, ... Wates, Percy J., Phœnix Gas-Works, Greenwich, S.E.

,, ... Williams, Alfred, 64, Bankside, S.E.

,, ... Wilshaw, W. G., 8, Clemence Street, Burdett Road, E.

,, ... Wilson, A. F., 34, St. George's Road, Southwark, S.E. [New Cross, S.E.

,, ... Wilson, Wm. Purvis, 220, Malpas Road

,, ... Woodall, Corbet (*Past President*), Phœnix Gas-Works, Bridge Foot, Vauxhall, S.W.

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Longport, Staffordshire	Henry Pratty, Gas-Works.
Longton, Staffordshire	James Malam Darwin, Gas-Works.
Lowestoft, Suffolk	W. H. Chambers, Gas-Works.
Low Moor, North Bierley, near Bradford	Frederick Bower, Gas-Works.
Ludlow, Salop	James Elliott, Gas-Works.
Lydd, Kent	W. R. Phillips, Gas-Works.
Lyons	*Emile Vautier, 36, Quai St. Antoine.
Lytham, Lancs.	Thos. Bower, Gas-Works.
Macclesfield, Chester	J. H. Lyon, Gas-Works.
" "	Thos. Moore, Gas-Works.
Madrid, Spain	Lucien Brémond, Compañia Madrileña de Alumbrado y Calefaccion por Gas.
Maidenhead, Berkshire	William Earl Beal, 5, High Street.
Maidstone, Kent	John West, Gas-Works.
" "	Henry Oswald Eldridge, Gas-Works.
Malta	William J. Jones, Gas-Works.
Manchester	Henry Newall (*Trustee and Treasurer*), 10, Marsden Street.
"	Henry Lyon, Barton House, Deansgate
"	James Braddock (*Mem of Com.*), Gas-Works, Rochdale Road. [City Road.
.. ..	William Brown, Victoria Foundry, 43,
"	†Alexander M'Dougall, jun., 68, Port Street.
"	†D. Murphy, Garratt Street Works, Oldham Road.
"	Thomas Newbigging, 5, Norfolk Street.
"	†David Vincent Steuart, Albert Chemical Works, Bradford. [Trafford.
"	Wm. Littlewood, 1, Lansdowne Villas, Old
"	Samuel Barratt, Gas-Works, Gaythorn.
"	†Geo. E. Davis, 87, Barton Arcade.
"	†John Woodward, Engineer.
Margate, Kent	Frederick Doughty, Gas-Works.
Marlborough, Wiltshire	Joseph Phelps, Gas-Works.
Merthyr Tydvil, Glamorganshire	John Lees Cocker, Gas-Works.
Messina, Sicily	Hilary Thomas Annis John, Gas-Works.
Middlesborough, Yorkshire	John Dunning.
" "	John Booth, jun., Gas-Works.

Middlesborough, Yorkshire	†S. A. Sadler.
Middleton, Lancashire	David Allan Graham, Gas-Works.
,, ,, ...	Christopher L. Hartley, Gas-Works.
Middlewich, Cheshire	Peter Hancock, Gas-Works.
Milan, Italy	C. W. Jones, Gas-Works.
Mitcham, Surrey	Benjamin Green, Gas-Works.
Monmouth, Mon.	Thos. Brace, Gas and Water Works.
Monte Video, Brazil	W. R. Jones, Gas-Works.
Morecambe, Lancashire	William Duff, Gas-Works.
Morley, near Leeds	William Croft, Gas-Works.
Moscow, Russia	Frederick Leslie, Gas-Works.
,, ,, ...	T. Parks, Gas-Works.
Nantwich, Cheshire	John Davies, Gas-Works.
Neath, Glamorganshire	C. S. Ellery, Gas-Works.
New Barnet	Thomas Henry Martin, Gas-Works.
Newcastle-under-Lyme, Stafford	William Winstanley, Gas-Works.
Newcastle-upon-Tyne	William Hardie, Gas Office.
,, ...	†Charles John Potter, Retort Manufacturer.
,, ...	†Wm. Richardson, Hebburn Colliery.
,, ...	†John Richd. Young, 3, Abbotsford Terrace, Moor Edge.
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Newmarket, Suffolk	Thomas Wilkinson, Gas-Works.
Newport, Isle of Wight	Joseph Reed, Gas-Works.
Newport, Mon.	Thos. Canning, Gas-Works.
Newry, Ireland	John Maraland, Gas-Works.
New Swindon, Wilts	John Joseph Jervis, Gas-Works.
Newton Abbot, Devon	Wm. Hy. Roberts, Gas-Works.
Newtown, Montgomeryshire	James Edmond, Gas-Works.
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Northampton	John Eunson, jun., Gas-Works.
Norwich, Norfolk	John Ayris, Surrey Street.
,, ,, ...	Fred. E. Linging, Gas-Works.
Nottingham	M. H. Loam, Gas-Works.
,, ...	Henry Warsop, Gas-Works, East Croft.
Oakengates, Salop	Geo. Parker, Gas-Works.
Oldham, Lancashire	John Chadwick, Gas-Works.
,, ,, ...	†Joseph Braddock, Globe Meter Works, Wellington Street.
,, ,, ...	Henry Thomas, Falcon Street.

Oldham, Lancashire	†Robert Newton, Union Street.
,, ,,	†Daniel Orme, Gas Meter Works, Park St.
Old Swindon, Wilts	Joseph Chapel Ashton, Gas-Works.
Oporto, Portugal	H. M. Layard Jones, Gas-Works.
Ormskirk, Lancashire	John Martin, Gas-Works.
Ossett, Yorkshire	Henry Legg, Gas-Works.
Oswestry, Salop	James Henry Parsons, Gas-Works.
Otley, near Leeds	George Edson, Gas-Works.
Oxford	*Dr. Wm. Odling, F.R.S.
Padiham, Lancashire	Joseph Richard Smith, Gas-Works.
Paisley, Renfrewshire	George R. Hislop, Gas-Works.
Paris, France	*Emile Durand, 72, Faubourg Montmartre.
,, ,,	Dimitri Monnier, 57, Rue Pigalle.
,, ,,	*Alfred Mallet, 54, Boulevard de la Villette.
,, ,,	*Eugène Lebon, 15, Rue Drouot.
,, ,,	*Edouard Servier, 18, Rue de Maubeuge.
Penrith, Cumberland	Edward Shaull, Gas-Works.
Pernambuco, Brazil	Charles A. Craven, Gas-Works.
,, ,,	T. Holmes, Gas-Works.
Peterborough, Northamptonshire	G. Ernest Stevenson, Gas-Works.
Pictou, Nova Scotia	J. D. Merriman, Gas-Works.
Plymouth, Devon	J. T. Browning, Gas-Works.
,, ,,	†W. Harvey, Lairn Works.
Plympton St. Mary, Devon	John Harris, Gas-Works.
Pontypridd, Glamorgan	†John Calvert.
Poole	John Budden, Gas-Works.
Portadown, Co. Armagh	Wm. Tait, Gas-Works.
Portishead, Somerset	Atchason V. Daniel, Gas-Works.
Portland, Dorset	G. R. Waters, The Grove.
Portsea, Hants	John Douglas (*Vice-President*), Gas-Works.
,, ,,	T. R. Crook, Gas-Works.
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,, ,,	William Prescott, Gas-Works.
Preston, Lancashire	Henry Green, Gas-Works.
Princes Risborough, Bucks	J. W. Dover, Gas-Works.
Queenstown, Ireland	Andrew Donaldson, Gas-Works.
Rainhill, Lancashire	Thomas Melling, Gas-Works.
Ramsgate, Kent	William A. Valon, Gas-Works.
,, ,,	T. C. Fuller, 2, St. Mary's Villas, The Elms.
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Redditch, Worcester	Thomas Layton, Gas-Works.
Red Hill, Surrey	Charles Read, Gas-Works.
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,, ,, ...	Edmund Bates Blott, Gas-Works.
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Rio de Janeiro, Brazil	John Ohren, Gas-Works.
Ripon, Yorkshire	Geo. Irvine, Gas-Works.
Rochdale, Lancashire	T. O. Paterson, Gas-Works.
Rochester, Kent	William Syms, Gas-Works.
,, ,, ...	George B. Vanheson, Gas-Works.
Romford, Essex	W. D. Child, Gas-Works, South Street.
Roscommon, Ireland	James Dunn, Gas-Works.
Ross, Herefordshire	James Harris, Gas-Works.
Rotherham, Yorkshire	James Goodwin, Gas-Works.
Rugby, Warwickshire	Peter Simpson, Gas-Works.
Runcorn, Cheshire	J. R. Frith, Gas-Works.
Ryde, Isle of Wight	George Garnett, Gas-Works.
Saffron Walden, Essex	Charles Wright, Gas-Works.
St. Albans, Herts	Arthur Frederick Phillips, Gas-Works.
St. Anne's-on-the-Sea, Lancashire	Thomas Stormonth, Gas-Works.
St. Helen's, Lancashire..	Edward Dyson, Gas Office.
,, ,, ...	Joseph Hall, Gas-Works.
St. John's, Porto Rico	J. E. Steinacher, Gas-Works.
St. Mary Church, Devon	Thomas Evans, Gas-Works.
St. Thomas, Dutch W. Indies ..	David Stiven, Gas-Works.
Salford	Samuel Hunter Gas-Works.
Salisbury	Thomas Hardick, Gas-Works.
Saltaire, Bradford	William Ambler, Gas-Works.
Sandown, Isle of Wight	Robert Marr, Gas-Works.
Sandwich, Kent	William Wells Woodruff, Gas-Works.
San Felipe, Chili	Edward Brickles, Gas-Works.
Santiago, Chili	George Hudson, Gas-Works.
Scarborough	Wm. James Moon, 16, York Place.
Seaham Harbour, Durham	J. Whyte, Gas-Works.
Selby, Yorkshire	Thomas Bell, Gas-Works.
Shaftesbury, Dorset	Ernest Yates, Gas-Works.
Sheerness, Kent	W. T. Carpenter, Gas-Works.
Sheffield, Yorkshire	Wm. Fergusson, Gas-Works, Neepsend.

Sheffield, Yorkshire	Wm. Watson, Gas-Works, Effingham St.
,, ,,	Wm. Parlby, Gas Office.
,, ,,	Wm. Romans, Gas Office, Commercial St.
Sherborne, Dorset	T. W. R. White, Gas-Works.
Shipley, near Leeds	William Wright, Alexandra Road.
Shotley Bridge, Durham	Thomas Bruce, Gas-Works.
Shrewsbury, Salop	S. B. Darwin, Gas-Works.
,, ,,	Thomas Walton, Gas-Works.
Silvertown, North Woolwich	John Wilton, Gas-Works.
Skipton, Yorkshire	S. Farey, Gas-Works.
Sleaford, Lincolnshire	Thos. Hy. Bouttell, Gas-Works.
Smyrna, Turkey	H. W. Andrews, Ottoman Gas-Works.
Southall, Middlesex	C. G. Shone, Brentford Gas-Works.
Southampton, Hants	S. W. Durkin, Gas-Works.
South Bank, Yorkshire	J. S. Nicholls, Gas-Works.
,, ,,	H. Harkewitz, Gas Office.
Southport, Lancashire	Robert Iddon, Gas-Works.
,, ,,	F. Pritchard, Gas-Works.
South Shields, Durham	W. J. Warner (*President*), Gas-Works.
,, ,,	William Belton, 5, Ravensbourne Terrace.
,, ,,	John Harper Penney, Gas-Works.
Sowerby Bridge, Yorkshire	G. E. Saville, Gas-Works.
Spalding, Lincolnshire	John Woodward, Gas-Works.
Stafford	John Storer, (*Mem. of Com.*), Gas-Works.
Stalybridge, Lancashire	R. Hunter, Gas-Works.
,, ,,	†Thomas Lockwood.
Stockport, Cheshire	James Jacques, Gas-Works.
Stockton-on-Tees, Durham	William Ford, Gas-Works.
,,	†W. Ashmore, Hope Iron-Works.
,, ,,	Robert Ford Gloag, Gas-Works.
Stoke-on-Trent, Staffordshire	John McMillan, Gas-Works.
Stourbridge, Worcestershire	William North, Gas-Works.
,, ,,	†Benjamin Gibbons, jun., Dibdale Retort-
,, ,,	†Wm. Corbett. [Works.
Stratford-on-Avon, Warwickshire	Job Seymour Cranmer, Gas-Works.
Sudbury, Suffolk	Charles William Grimwood, Gas-Works.
Sunbury-on-Thames, Middlesex	John Smith, Gas-Works.
Sunderland, Durham	John H. Cox, Gas Office.
Sutton, Surrey	F. Mead, Gas-Works.
,, ,,	C. Roper Mead, Devon Lodge, Grove Road.
Sutton-in-Ashfield, Notts	W. A. Plumbe, Gas-Works.
Swansea	Thornton Andrews, Gas-Works.

Swindon, Wilts	Henry Hunt, Gas-Works.
Sydney, New South Wales	T. J. Bush, Gas-Works.
,, ,, ...	William Henry Stephen, Gas-Works.
Tamworth, Staffordshire..	Thomas Bull, Gas-Works.
,, ,, ...	E. Sapey, Gas-Works.
Taunton, Somerset	A. J. Edwards, Gas-Works.
Tavistock, Devon	C. Terdrey, Gas-Works.
Tenbury, Worcestershire	William Ashley, Gas-Works.
Thorne, Yorkshire	Henry Peeks, Gas-Works.
Tiverton, Devon	William Cuthbert Bennett, Gas-Works.
Todmorden, Lancashire	H. A. Coles, Gas-Works.
Torquay, Devon	James Greenfield, Hollacombe, Paignton.
Tottenham	James Randall, Gas Office.
,, ...	W. H. Broadberry, Gas-Works.
Traleb, Ireland	James Surl, Gas-Works.
Tredegar, Monmouthshire	Henry F. Wells, Gas-Works.
Trowbridge, Wilts	Henry Sainsbury, Gas-Works.
Truro, Cornwall	Jas. Greenaway, Gas-Works.
Tunbridge Wells	John Read, Gas Office.
,, ...	Geo. Scott, Gas-Works.
Tunstall, Staffordshire	Samuel Watson, Gas-Works.
Ulverston, Lancashire	J. Hodgson, Church Walk.
Uxbridge, Middlesex	John Russell, Gas-Works.
,, ,, ...	Edwin Cotton, Gas-Works.
Uttoxeter, Staffordshire..	Stephen Murray, Gas-Works.
Ventnor, Isle of Wight	John G. Livesay, Gas-Works.
,, ,, ...	Wm. T. Leach, Gas and Water Office.
Vienna, Austria	J. Pazzani, Gas-Works, Belvedere.
Wadebridge, Cornwall	John Martyn, Gas-Works.
Währing, Vienna, Austria	J. E. Bengough, jun., Gas-Works.
Wakefield, Yorkshire	John William Whitaker, Gas-Works.
,, ,, ...	George Hart, West Riding Asylum.
Walker, near Newcastle-on-Tyne	Thomas Forrest, Gas-Works.
Wallasey, Cheshire	Edmund H. Harris, Gas-Works.
Walsall, Staffordshire	John Tindall, Gas-Works.
Waltham, Essex	Harry Townsend, Gas-Works.
Wandsworth, Surrey	John Middleton, Gas-Works.
,, ,, ...	Hy. Somerson Freeman, Gas-Works.
Ware, Herts.	R. P. Thomas, Gas-Works.

Warrington, Lancashire	Jas. Paterson (*Past President*), Gas-Works.
Watchet, Somerset..	Walter Lewis Copp, Gas-Works.
Wellington, Somerset	Henry G. Crowe, Gas-Works.
Wells, Somerset	C. Brown, Gas-Works.
West Cowes, Isle of Wight	Alfred Barton, Union House.
West Hartlepool, Durham	Thomas Trewhitt, Gas-Works.
„ „	Thomas Mossman, Gas-Works.
Wexford, Ireland	John Lyne, Gas-Works.
Weymouth, Dorset	Thomas Stone, Gas-Works.
Whitchurch, Shropshire	Charles Frederick Hassall, Gas-Works.
Whitehaven, Cumberland	Shadrach Studholm, Gas-Works.
„ „	George Cutler, New Gas-Works.
Whitworth, Lancashire..	Edmund Lord, Gas-Works.
Wigan, Lancashire	J. G. Hawkins, Gas-Works.
„ „	Thomas Smith, 17, King Street.
Willington Quay, Newcastle-upon-Tyne	†Addison Potter.
„ „	Geo. A. Allan, Gas-Works.
Winchester, Hants..	William Upton Tinney, Gas-Works.
Windsor, Berkshire..	James Wadeson, Gas-Works.
Winsford, Cheshire	Hy. Ward Carter, Gas-Works.
Wolverhampton	John Annan, Gas-Works.
Wolverton, Bucks..	Robert King, Stratford Road.
Woodford, Essex	Allan Brown, Gas-Works.
Woolton, Lancashire	H. Hatch, Gas-Works.
Woolwich, Kent	William White, Equitable Gas-Works.
„ „	James Hunter, Consumers' Gas Company's Works.
Worcester	Josiah Deakes, Gas-Works.
Worksop, Nottinghamshire	William Bates, Gas-Works.
Worthing, Sussex	J. Richmond, Gas-Works.
Wrexham, Denbigh	Thos. Walker, Gas-Works.
Yeovil	E. Howell, Gas-Works.
York..	C. Sellers, Gas Office.
Ystrad, Rhonda Valley, Glamorganshire	E. S. Pike, Gas-Works.

THE

BENEVOLENT FUND

OF THE

British Association of Gas Managers.

OFFICERS.

Chairman.

W. J. WARNER (President of the British Association of Gas Managers), Gas-Works, South Shields.

Trustees.

HENRY NEWALL, 10, Marsden Street, Manchester.
GEORGE T. LIVESEY, South Metropolitan Gas-Works, Old Kent Road, London, S.E.
W. J. WARNER, Gas-Works, South Shields.

Committee.

ROBERT P. SPICE, 21, Parliament Street, Westminster, S.W.
W. J. WARNER, Gas-Works, South Shields.
E. GODDARD, Gas-Works, Ipswich.
JOSEPH HEPWORTH, Gas-Works, Carlisle.
J. R. FRITH, Gas-Works, Runcorn.
JOHN STORER, Gas-Works, Stafford.

Finance Committee.

GEORGE T. LIVESEY, South Metropolitan Gas-Works, Old Kent Road, London, S.E.
G. W. STEVENSON, 4, Westminster Chambers, Victoria St., Westminster, S.W.
JAMES ELDRIDGE, Gas-Works, Richmond, Surrey.

Auditors.

ALFRED HERSEE, 29, Great St. Helen's, London, E.C.
ALFRED LASS, 80, Gracechurch Street, London, E.C.

Secretary.

W. H. BENNETT, 22, Great George Street, Westminster, S.W.

RULES.

Name.

1. This Institution shall be called "THE BENEVOLENT FUND OF THE BRITISH ASSOCIATION OF GAS MANAGERS."

Object.

2. The object of the Benevolent Fund is to afford assistance to necessitous members of the British Association of Gas Managers, and their families, and to the families of deceased members, or to any one, or to the family of any one, who may have been a member, whether such member shall have been a contributor to the Benevolent Fund or not.

Capital and Income.

3. The fund shall be supported by means of Donations and Bequests, and Annual Subscriptions of not less than ten shillings and sixpence.

4. All donations and bequests received or promised prior to May 1, 1877, shall be considered as capital, and shall be invested, in the names of the Trustees of the British Association of Gas Managers' Benevolent Fund, in Government or in East India Securities, or in Bank of England Stock, or in debentures or guaranteed stock of any railway, or gas company, or water company, in Great Britain or Ireland or in India, paying a dividend; and no part of such funds so invested shall be withdrawn from capital, except by

a resolution authorizing such withdrawal passed at a General Meeting of the contributors specially convened for the purpose.

5. All donations and bequests received or promised, subsequent to April 30, 1877, shall, unless otherwise directed by the donors, be available for affording assistance to the persons eligible to receive such assistance, subject to the limitation contained in Rule 8.

6. All annual subscriptions, and all dividends and interest arising from capital, shall be considered as income, and shall be applicable to the payment of grants and the assistance of applicants, and to the payment of necessary charges and expenses.

7. The accumulation of income, unexpended donations, and bequests (if any) which may accrue from year to year, after payment of all the grants and other charges and liabilities of the fund, may in the discretion of the Committee of Management be invested.

8. The Committee of Management may, out of donations, bequests, and income, apply in assistance in the first year a sum amounting to the income of that year; and in subsequent years a sum not exceeding twice the income of any preceding year, as defined in Rule 6; and it shall be competent for any General Meeting to authorize the application of a larger sum.

Privileges of Contributors.

9. The following contributors to the fund shall be entitled to vote at all General and Extraordinary General Meetings, and for the election of the Committee by ballot, as follows:—

> Annual subscribers of not less than ten shillings and sixpence shall have one vote for every ten shillings and sixpence subscribed; and donors of not less than £5 in one payment shall have one vote for every £5 so given.

10. Votes may be recorded either personally or by proxy upon all questions, excepting the election of the Committee of Management,

and for such election they may be recorded by delivery to the Scrutineers, either personally or through the Secretary, of a list issued by the Committee under Rule 30 of the British Association of Gas Managers, after erasure or substitution, by the voter, of names thereon in accordance with the conditions named therein.

11. Annual subscriptions shall be payable in advance on the 1st of January in each year, and no subscriber, whose subscription is in arrear, shall be entitled to any privileges as to voting.

Committee of Management.

12. For conducting the affairs of the fund there shall be a "Committee of Management" consisting of the President for the time being of the British Association of Gas Managers as chairman, and six other members, elected in accordance with Rule 10, three to form a quorum. The Committee so elected shall hold office for three years, at which time they shall retire, but be eligible for re-election.

13. The Committee of Management shall have full power to make grants and afford assistance to any necessitous member or members of the British Association of Gas Managers, or to their families, or to the family or families of any deceased member or members; also to any one who may have been a member, or to the family of such person, whether such person shall be or shall have been a contributor to the fund or not; and the fact of having been a contributor to the fund shall not in any case constitute a claim to participate in it, but the cases of those who have been contributors to the fund shall receive prior consideration, other circumstances being equal. Any attempt on the part of an applicant to canvass either the Committee or the members generally, shall render such applicant ineligible for assistance.

14. The Committee of Management may for the conduct of the affairs of the fund from time to time make such regulations, not being inconsistent with these Rules or with the Rules of the British Association of Gas Managers, as they shall deem expedient.

15. The mode of application for grants and assistance, and the nature of the recommendations to be required in support thereof, the qualifications and merits of the applicants, the amounts of the grants in individual cases, and also the purposes to which such grants shall be applied, and the advisability of their renewal, shall in every case be left to the determination of the Committee of Management.

16. The Committee of Management shall have power to make investments in the names of the Trustees.

17. The Committee shall not make any grants or payments by which the donations, bequests, or income of future years shall be anticipated or appropriated.

Meetings.

18.—A General Meeting of the contributors to the fund shall be annually held on one of the days appointed for the meeting of the British Association of Gas Managers, and at such meetings a report of the Committee shall be presented, containing the names of all the contributors to the fund, a statement of the number and amounts of all the grants made and assistance afforded during the past year up to and inclusive of the 31st day of December, and of the general state of the fund on the last-named day; but it shall not be necessary to publish the names of the applicants for, and the recipients of, the assistance afforded by the fund, and the accounts shall be produced, certified by the auditors of the British Association of Gas Managers.

19.—An Extraordinary General Meeting may be called as often as the Committee shall deem necessary, and also whenever the President shall be required in writing to do so by twenty contributors to the fund, specifying the object for which they desire such meeting to be called, but no business shall be transacted at such meeting, or at any adjourned meeting thereof, other than that specified in the requisition.

20.—The presence of at least ten contributors to the fund shall

be necessary for the transaction of business at either a General or an Extraordinary General Meeting, and if that number be not present within half an hour of the time appointed, the contributors present may adjourn the meeting to any day not more than thirty days from the day of the original meeting.

21.—All questions introduced at any General or Extraordinary General Meeting shall be decided by the votes recorded in accordance with Rule 10, and should the votes be equal, the Chairman may give a casting vote. Provided always, that no motion for altering the objects of the fund, or for diverting any portion of the funds from the purposes herein specified, be adopted, unless at an Extraordinary General Meeting summoned for the express object of discussing such motion, and unless the same be carried by a majority of at least three-fourths of the votes given at such meeting.

Secretary.

22. The Secretary of the British Association of Gas Managers shall be the Secretary to the fund.

Auditors.

23. The Auditors of the British Association of Gas Managers shall be the Auditors of the fund.

Bankers.

24. The banking account of the fund shall be kept at a bank in the Metropolis to be approved by the Committee, and the first bankers shall be the London and County Bank. Lambeth Branch.

Trustees.

25. Three Trustees shall be appointed at the first Annual General Meeting, in whose names shall be invested all the property of the fund, except such as shall be from time to time in the hands of the Committee; and when any vacancy arises it shall be filled up by a General Meeting to be specially convened for the purpose, and the remaining Trustees shall immediately transfer all property and funds into the names of themselves and the new Trustee.

26. Each of the said Trustees shall be chargeable only for such moneys, funds, and securities as he shall actually receive, notwithstanding his signing any receipt for the sake of conformity, and shall be answerable and accountable only for his own acts, receipts, neglects, or defaults, and not for those of the other Trustees, nor for any Banker, Broker, or other person with whom any trust moneys or securities may be deposited, nor for the insufficiency or deficiency of the said moneys, funds, or securities, nor for any other loss, unless the same shall happen through his own wilful neglect or default.

27. The Trustees shall from time to time pay over the dividends, interest, and annual income arising from the property of or belonging to the fund, to, or permit the same to be received by, the Committee of Management for the time being.

British Association of Gas Managers'

BENEVOLENT FUND.

LIST OF SUBSCRIPTIONS & DONATIONS

Paid during the Year ending December 31, 1877.

Name.	Address.	For the Year.	Subscriptions. £	s.	d.	Donations. £	s.	d.
Ambler, W.	Saltaire	1877		10	6			
Aird & Sons, J.	London	„	5	5	0	105	0	0
Anderson, G.	London			—		52	10	0
Aird, J.	Great Bridge	1877	1	1	0			
Bowen, H.	Cardiff			—		10	0	0
Ball, T. B.	New Wortley	1877	1	1	0			
Bickerton, G.	Goole	1878		10	6			
Brett, R. W.	Hertford	1877		10	6			
Breillat, E.	Bristol			—		5	0	0
Botley, C. E.	Wormwood Scrubs	1877		10	6			
Broadberry, W. H.	Tottenham			—		2	2	0
Booth, jun. J.	Middlesborough	1877		10	6			
Bryan, E.	Beverley	„		10	6			
Church, J.	London	1877	1	1	0			
Cutler, G.	Whitehaven	„		10	6			
Church, G.	London	1878		10	6			
Cross, S.	Abergavenny	1877		10	6			
Coombs, J. A.	Cheltenham	„		10	6			
Darwin, J. M.	Longton	1877		10	6			
Dixon, C.	Horncastle	„		10	6			
Darney, R.	Faversham	„		10	6			
Doughty, F.	Margate	„		10	6			
Dempster, R.	Elland	„	3	3	0			
Edmond, J.	Newtown	1877		10	6			
Elliott, J.	Ludlow	„		10	6			
Edwards, A. J.	Taunton	1878		10	6			
Ely, J.	Abingdon	1877		10	6			
Frith, J. R.	Runcorn	1878	1	1	0			
Farrand, C.	Croydon	1877		10	6			
Farrand, F. F.	Acton	„		10	6			
Furnivall, G. S.	Bradley Green	„	1	1	0			
Fuller, T. C.	Ramsgate	„		10	6			
	Carried forward		£24	18	6	£174	12	0

Name.	Address.	For the Year.	Subscriptions. £	s.	d.	Donations. £	s.	d.
	Brought forward		24	13	6	174	12	0
Grimwood, C. W.	Sudbury	1877		10	6			
Good, R.	Carshalton	„		10	6			
Goddard, E.	Ipswich	„	1	1	0	10	0	0
Garnett, G.	Ryde			—		5	5	0
Horsley, C.	London			—		25	0	0
Hunter, R.	Stalybridge	1877		10	6			
Hunt, C.	Birmingham	„	1	1	0	5	5	0
Howell, E.	Yeovil	„		10	6			
Hunter, S.	Salford	„		10	6			
Hepworth, J.	Carlisle			—		5	0	0
Hepworth, J., a Friend per	Carlisle			—		5	0	0
Hammond, W. R.	Deal	1877		10	6			
Hancock, P.	Sandbach	„		10	6			
Hunter, J.	Woolwich	1878		10	6			
Hartley, F. W.	London	1877	1	1	0			
Hislop, G. R.	Paisley			—		5	5	0
Irons, G. B.	Gosport	1877		10	6			
Jones, R. H.	Dover	1877	1	1	0			
Jolliffe, J. T.	Hendon	„		10	6			
Lass, A.	London	1877	1	1	0			
Livesey, G.	London	„	1	1	0			
Lord, E.	Whitworth	„		10	6			
Legg, H.	Ossett	„		10	6			
Marr, R.	Sandown	1877		10	6			
Murray, S.	Uttoxeter	„		10	6			
Mead, F.	Sutton	„	1	1	0			
May, T.	Canterbury	„		10	6			
Mossman, T.	W. Hartlepool	„		10	6			
Mildred, M.	London	„	1	1	0			
Martin, J.	Ormskirk	„		10	6			
Murphy, A. M.	Cirencester	„		10	6			
Macnie, J.	Londonderry	1878		10	6			
Niven, J.	Clayton	1877	1	1	0			
Osborn, G. H.	Bromley	1878		10	6			
Ohren, M.	Lower Sydenham			—		5	0	0
Ohren, J.	Rio de Janiero			—		5	0	0
Oakes & Co., J.	Alfreton			—		75	0	0
Parsons, J. H.	Oswestry	1877		10	6			
Parsons, W.	Atherstone	„		10	6			
Paterson, J.	Warrington	„	1	1	0			
Penney, J. H.	South Shields	„		10	6			
Phelps, J.	Marlborough	„		10	6			
Peebles, D. B.	Edinburgh			—		5	0	0
Proud, T.	Birmingham	1877	1	1	0			
Packham, H. F.	Kingston	„	1	1	0			
Reeves, J. S.	Bilston	1877		10	6			
Russell, J.	Uxbridge	„		10	6			
Riley, F.	Bishop's Stortford	„		10	6			
Russell, F.	Ilfracombe	„		10	6			
Randall, J.	Tottenham			—		2	2	0
Richmond, J.	Worthing	1877		10	6			
Ross, R.	Hiogo	„		10	6			
	Carried forward		£53	0	6	£327	9	0

Name.	Address.	For the Year.	Subscriptions. £	s.	d.	Donations. £	s.	d.
	Brought forward		53	0	6	327	9	0
Shaul, E.	Penrith	1878	1	1	0			
Sainsbury, H.	Trowbridge	1877		10	6			
Stevenson, G. W.	London	1877	1	1	0	20	0	0
Stansfield, W.	Exeter	,,		10	6			
Spice, R. P.	London	,,	1	1	0	10	0	0
South Shields Gas Co.	South Shields			—		5	5	0
Stephenson, H. P.	London	1877	1	1	0			
Smith, J. R.	Padiham	1878		10	6			
Travers, T.	Cork	1877		10	6			
Thomas, R. P.	Ware	,,		10	6			
Trewhitt, T.	West Hartlepool	,,		10	6			
Valon, W. A.	Ramsgate	1877	1	1	0			
Wadeson, J.	Windsor	1877		10	6			
Wright, W.	Shipley	,,		10	6			
Waller & Co., G.	London	,,	2	2	0			
Webb, T.	Egham	,,		10	6			
Warner, W. J.	South Shields			—		5	5	0
Willis, W. H.	Great Yarmouth	,,		10	6			
Wimhurst, H.	Andover	,,		10	6			
Walker, W. A.	Elland	,,		10	6			
Woodall, C.	London	,,	2	2	0			
Wilkinson, T.	Newmarket	,,		10	6			
Waters, G. R.	Portland	,,		10	6			
West, J.	Maidstone	,,	1	1	0			
			£70	17	6	£367	19	0

BRITISH ASSOCIATION OF GAS MANAGERS.

BENEVOLENT FUND.

Dr.				Cr.			
May 1, 1877.		£	s. d.	Dec. 4, 1877.		£	s. d.
To Balance brought forward		262	16 2	By Clayton & Co., General Printing .	£6 1 0		
Dec. 31.				Ditto, Printing Reports .	8 2 9		
To Donations	£367 19 0					14	3 9
„ Subscriptions	70 17 6			„ Waterlow & Sons (Stationery) . .		3	15 0
		438	16 6	„ Petty Cash Disbursements . . .			15 6
				At Banker's	£675 12 1		
				In Secretary's hands	7 6 4		
						682	18 5
		£701	12 8			£701	12 8

Audited and found correct,

(Signed) ALFRED HERSEE, ALFRED LASS, *Auditors.*

25th March, 1878.

Since the above account was made up, Messrs. C. & W. Walker's promised donation of £100 has been received.

LONDON
CLAYTON AND CO., TEMPLE PRINTING WORKS,
BOUVERIE STREET, WHITEFRIARS.